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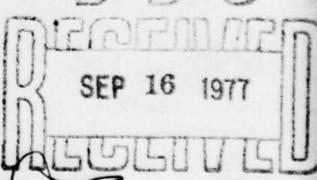
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⑩ John G./Johnson, Major, USAF
Richard G. Wilmes, Major, USMC

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    This thesis evaluated three separate methods currently used in the Department of Defense to determine the region of economic influence around a military installation. Mathematical models for prediction of employee distributions in the region of influence were also evaluated. When applied to data containing information on all civilian and military personnel at Wright-Patterson AFB, Ohio all three methods proved effective in identifying regions where 90 percent or more of the base employees lived, but the method used by the U.S. Army Construction Engineering Research Laboratory was both effective and simple to use. A variation of a gravity model was found highly effective in predicting the distribution of employees as a function of county population and the distance from the base to the county. The consideration of annual wages was found to add little to the study of the region of influence with the distribution of wages following the distribution of employees very closely. The possibility of using zip code areas as basic statistical units was found less desireable due to higher variances in model performance.

THE REGION OF ECONOMIC INFLUENCE

AROUND A MILITARY INSTALLATION •

A Thesis

Presented to the Faculty of the School of Systems and Logistics

of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Facilities Management

By

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This thesis, written by

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Charles E. Ebeling
COMMITTEE CHAIRMAN

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CHAPTER I

INTRODUCTION

Statement of the Problem

The National Environmental Policy Act (NEPA) was signed
into law on January 1, 1970. It is the stated policy of the Federal
government that before any decisions on Federal activities or programs
are made by any agency, the responsible officials of that agency shall
carefully and thoroughly assess the action's possible consequences to
man's environment. Programs conducted by the Department of Defense
have the potential of extreme influence on the economic quality of the
environment of communities surrounding military installations and,
therefore, must be examined in the light of NEPA. The region of eco-
nomic influence around a point is more difficult to determine than the
area of ecological effect, but the courts have ruled economic influence
important to consider in the decisions of Federal agencies. Yet, the
basic problem exists: there is no generally accepted method for defin-
ing the region of economic influence around a military installation
(22:24) for an environmental impact assessment. This creates an
inherent susceptibility to charges of arbitrariness and capriciousness

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(20:8ERC1154) in the selection of areas for analysis in making impact assessments.

Background

In discussing NEPA an independent research group said, ". . . the statute is so broad, yet opaque, that it will take even longer than usual to fully comprehend its import [14:3]." The purpose of the act is to ". . . encourage productive and enjoyable harmony between man and his environment . . . and fulfill the social, economic, and other requirements of present and future Americans [16]." NEPA provisions are binding on all activities of the Federal government. It requires that careful consideration be given to any major activity which might significantly affect the quality of the human environment. If the impact of such activities by a Federal agency is considered significant, an Environmental Impact Statement (EIS) will be completed by the responsible Federal official of that agency for the purpose of outlining:

(i) the environmental impact of the proposed action,
(ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
(iii) alternatives to the proposed activities,
(iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long term productivity, and
(v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be taken [16].

The Department of Defense (DoD) reiterated this national policy and issued specific instructions for its component agencies to:

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. Assess at the earliest practical stage in the planning process and in all instances prior to the first significant point of decision the environmental consequences of proposed actions.

. Use a systematic interdisciplinary approach in planning and decision making.

. Prepare and process, under criteria contained in the directive, a detailed environmental impact statement on every recommendation or report on proposals for legislation and on other major defense actions which are expected to be environmentally controversial or significantly affect the quality of the human environment.

. Study, develop, and describe appropriate alternatives to the recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources [19].

The importance of considering socio-economic factors in Environmental Impact Assessments (EIA) was demonstrated to the DoD in several court cases. The Department of the Army was enjoined on October 31, 1975 from proceeding with the proposed transfer of functions of the Lexington-Bluegrass Army Depot from Kentucky to depots in California and Pennsylvania for failure to properly assess the physical and sociological impacts the proposed transfer would have upon the greater Lexington, Kentucky area (2). The Department of the Navy faced similar action in two court cases in 1975 contesting the expansion of existing facilities in the states of Mississippi and Washington (7; 13). In the Department of the Air Force, realignment at Richards-Gebaur AFB has been delayed indefinitely due to the EIA's failure to fully consider all aspects of impact on surrounding communities. Since June 19, 1975 the Air Force has been "enjoined and prohibited" by the court (20) from making a decision on the realignment action. Savings would have

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been an estimated $11 million through June 30, 1976 and $16 million annually thereafter (20:12). Although the provisions of NEPA were seriously considered in forming the EIA for Richards-Gebaur, the presiding Federal judge's injunctive decision said, " . . . no attempt was made to determine whether that impact would be spread across the greater Kansas City area or localized in the areas immediately surrounding the base . . . [20:21]." Throughout the decision, the court was critical of the Air Force's failure to use a "systematic, interdisciplinary approach" as directed by NEPA (20:68). Additionally, testimony revealed that the EIA was made with data gathered solely in Washington, D.C. (20:13).

The Department of the Army responded to environmental policy by tasking the Construction Engineering Research Laboratory (CERL)[1] at Champaign, Illinois to develop a computer based aid for preparing impact assessments (15:18). The result was the Environmental Technical Information System (ETIS), designed to provide expert technical information to installation commanders for the complete and objective assessment of the environmental impacts of Army programs, as required by NEPA and DoD directives (23:ii). ETIS embodies the

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[1]The Construction Engineering Research Laboratory was established in 1968 to support the Office of the Chief of Engineers (OCE) of the Department of the Army. CERL's Environmental and Energy Systems Division is involved in comprehensive environmental research to be responsive to the provisions of the National Environmental Policy Act, Executive Orders, and Department of Defense guidelines (18:1).

contributions of a wide range of physical and social scientists with backgrounds in ecology, the health sciences, sociology, economics, geology, and other fields. Three subsystems comprise ETIS: (1) the Environmental Impact Computer System, (2) the Computer-Aided Environmental Legislative Data System, and (3) the Economic Impact Forecasting System (EIFS). The third system makes regional economic information available to military agencies for better compliance with NEPA policy as defined by the cited court actions. EIFS operates a model developed by CERL scientists and authoritative economic consultants to analyze the effects of Army activities in a number of functional areas. The system is essentially operational for economic analysis in the areas of construction, operations and maintenance, training, and mission changes, with five additional functional areas under various stages of development. The proposed regional definition in EIFS is based on a gravitational concept from marketing theory in which the employment distribution of an installation is considered to be a function of regional population and distance to travel to work.

The work by CERL has put the Army in a leadership position in the use of modern technology to " . . . encourage productive and enjoyable harmony between man and his environment [16]." The Air Force has recognized the value of the Army developments and has established a user linkage with EIFS through CERL to share the technology in improving assessments and decision making in future base

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realignment activities. According to Ronald D. Webster, principle

investigator for CERL's Environmental Systems Team, the necessity

for operational capability has resulted in EIFS being applied to real-life

problems concurrently with system development and refinement (21).

Consequently, sensitivity of forecasts has been dependent on the "state-

of-the-art" as it has developed on a day to day basis.

A major factor in the EIFS program, representing a positive

response to the Federal court's criticism in the Richards-Gebaur case,

is a scientific evaluation of economic impact in cities and communities

surrounding installations subject to Federal programs. The system

discriminates in the degree of forecasted impact among the various

communities in relation to the proportion of military and civilian

employee personnel to total population residing in given areas (10:4).

A region of economic influence is defined for each individual installa-

tion by forming a composite area of near-by counties which might be

affected by Federal activities and programs conducted at that installa-

tion (21). EIFS uses the most current information available from the

Department of Commerce (Bureau of Census and Bureau of Economic

Analysis), the Department of Defense, and the Department of Health,

Education and Welfare to calculate the distribution of impacts within

this region of economic influence (23:1). A review of CERL, Army,

and Air Force guidelines for definition of the region to be analyzed by

EIFS results in three separate methods in general usage with little work

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done, to date, to objectively validate any one of the three. Each of these methods defines the economic region by analysis of the location of employee residence. This type of analysis has good support in marketing theory (5:288; 8:165; 9:104).

CERL has found that an area composed of counties wholly or partially included within a 30 mile radius of an installation is an easily determinable region and has been found satisfactorily accurate during system development (21). The Air Force Civil Engineering Center (AFCEC) at Tyndall AFB, Florida has a direct tie-in with CERL's computer and is using EIFS in direct applications defining the economic regions of influence around Air Force bases by aggregating an area of all counties containing communities within one hour driving distance of each base. According to Captain Richard Padgett (12) in AFCEC's Environmental Division, the one hour driving distance limit has its basis in DoD criteria for determination of adequacy of housing for military personnel in a given area.[2] Mr. Berry Cantor of the Army's Directorate of Cost Analysis explained that the Army's method for defining economic regions of influence is to include all counties whose Federally employed residents (for one particular base) make up two percent or more of the total county work force (4). This rule is subjectively modified in special cases to include additional centers of potential

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[2]It is interesting to note the implicit support given this criteria by the Federal court in addressing Air Force officials' assessment of available housing in the Scott AFB, Illinois area as a part of the realignment study in the Richards-Gebaur Case (20:32).

employment when the area defined under the two percent criteria is incapable of absorbing employment impacts that could arise due to Army base realignment. The Office of the Comptroller of the Army has also published a list of predefined "economic communities" in a report on "Economic Multipliers for Army Base Realignment Studies (17)."

The CERL Model

Fundamental to the Construction Engineering Research Laboratory's efforts in determining the economic region of influence around a military installation is the determination of the residential distribution of the installation's employees. Locating the residences of employees of an installation by county area determines which counties are included in the installation's socio-economic region. CERL developed an algorithm which determined the proportion of a county's total employment working at the military installation. These proportions were summed for all counties in the potential economic region of influence, and then an average was computed for use as a standard against which individual county proportions could be compared to assess whether the installation's employment in a given county was or was not economically significant. CERL decided that if a county's proportion of employment was greater than the average proportion for the potential region, it would be included in the region of economic influence.

This method of analysis, however, requires readily available data indicating military and civilian employee residence location by

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county. When CERL attempted to apply this method, they found that the data either did not exist or was not in a form that was usable.

A second model has been proposed for use in EIFS to determine the employee residence distribution theoretically which could eliminate some of the problems with data collection. The proposed model is of the form:

$$E_{aj} = k \frac{(P_j)}{D_{aj}}$$

where

E_{aj} = total employment at site a from county j

P_j = population of county j

D_{aj} = distance between site a and county j

k = proportionality constant

This model indicates that the number of employees with residence in county j is related directly with the population of county j and inversely proportional to the distance from county j to the installation (10).

The concept for this model can be traced back to Newton's Universal Law of Gravitation, which says, "Every particle of matter in the universe attracts every other particle with a force that varies directly as the product of their masses and the square of the distances between them [1:118]." Marketing research has used this principle very successfully in explaining the business attraction of a retail area in terms of population and driving distances (8:165). The CERL

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application of the principle is a variation of the general law in that distance is assumed to be a first order variable in the equation. The proposed model has not yet been thoroughly tested, however. One of the objectives of this research is to apply the model to data available at Wright-Patterson AFB and evaluate the employee residence distribution prediction at a major military installation.

Justification

The proposed definition of the region of economic influence used in EIFS has been tested only at two small Army installations for which data was readily available (CERL and Harry Diamond Laboratories). Based on previous knowledge of the installations and their surroundings, the tests were considered valid (10:2); however, there have been no further tests or validation attempts using actual case data for major military installations. Dr. Ravi K. Jain, Chief, Environmental Division at CERL, specified the need for this research effort to define the "economic region" in order to clarify future effort in this regard as it pertains to data requirements, validity, reliability, and practicality (10:1).

There is a recognized need to standardize a definition of the economic region of influence in order that military programs and activities can be analyzed precisely and identically with regard to method. Court action has proven costly in time and money, and the potential for further legal entanglement will remain high while impact

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assessment methodology is dependent on which branch of DoD is performing the study.

Scope

This research was concerned with the determination of the region of influence around a military installation--a determination that must be made prior to judgment of impact significance. The problem was limited to analysis of residence and wage distributions of employees at Wright-Patterson AFB, Ohio. Employee residence locations and gross annual wages were the only factors considered in the analysis of the methods of economic region definition. The selection of this base was made because of the availability of data and the convenience of its location. The decision to limit this research effort to a single installation was necessary due to constraints in time and resources. Research at additional installations, which may be required for greater conclusiveness of results, will be left for future efforts.

Research Objectives

The objectives of this research were to evaluate methods of determining the region of economic influence around Wright-Patterson AFB and to identify the most effective methods to use in Environmental Impact Assessment efforts. Methodology was developed whereby the research can be repeated at additional installations with the long term

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objective of identifying methods of regional definition for general use

within the Department of Defense.

CHAPTER II

METHODOLOGY

Overview

This research limited consideration of factors involved in
defining the region of economic influence around a military installation
to the effects of Federal employment and Federal wage expenditures at
Wright-Patterson AFB, Ohio. Such economically related matters as
education funding, welfare programs, and charities were left as
subjects for other studies. The universe of economic influence under
consideration was composed of the region within a 100 mile radius of
Wright-Patterson AFB, with the people, residences, post offices, zip
code areas, and counties that it contains. The military and civilian
employees at Wright-Patterson AFB formed the population for the
study. The relatively few employees of service contractors on the
base earning wages indirectly from the Federal Government were
excluded. Their residential distribution, wages and general effects
on the region were assumed to be essentially the same as the directly
employed Federal workers. The indeterminable number of workers
and the amount of their wages, thus excluded, are considered small

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in comparison to the 28,495 employees of the population, so the effects of this omission should be minimal.

The first phase of this study was the evaluation of the three primary methods of region definition currently used by DoD in economic impact assessment and the determination of their relative successes in circumscribing the dispersion of employees and wages in the surrounding communities. All three methods have the common basis of determination of the economic region by locating the places of residence of the base employees. The methods were evaluated by ranking them according to the percentages of total employees and wages enclosed within the defined region. The methods were also evaluated to determine if support exists for the criterion currently used by CERL and the Air Force and the threshold significant percentage of county employment used by the Army. Incremental variations in the criterion were investigated to determine the marginal rate of change in employees and wages enclosed within the described region. Varying the radius used in the CERL method and the rectilinear driving distance (analogous to driving time) used in the Air Force method allowed graphs to be constructed to identify the dimensions where method improvement diminishes. Plotting the percentages of total employees enclosed by the Army method against threshold significance percentages displayed the rate of change that accompanied the consideration of successively smaller concentrations of Federal employees. The graphs were used to support present

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dimensions or to suggest adjustments in each of the methods as they were applied at Wright-Patterson AFB.

The second phase of this study was an investigation of the employee residential distribution and the population of the residential area in relation to the distance to drive to work. Two different approaches were taken. Data were aggregated by zip code and by county. Curve fitting by the least-squares method (LSM) was performed on the data in various forms of the gravity model to determine the most appropriate functional form. The data were analyzed using CERL's proposed model, then modified by squaring the distance variable. Other functional forms were examined by raising the distance variable to the third power and the fourth power and the population variable to the second power and the 1.5 power. In another form for analysis, exponents of both the population and the distance variables were estimated using the least-squares technique. This was the most general approach based upon the gravity model. As an alternative to the gravity form, the data were also fitted by combining the variables in the common additive form.

Design of the Study

Employees and their wages were summed in residential area classifications by use of their zip code mailing addresses as listed in the pay records. Employee and wage distribution analysis was simplified by considering zip code area effects to be concentrated at the post

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office serving each area and measuring driving distances between the post office and Air Force Logistics Command Headquarters (Building 262) on the base. The post office was assumed to be the center of population for a zip code area and Building 262 was assumed to be the center of employment for the combined Areas A, B, and C of Wright-Patterson AFB. Building 262 is, incidentally, the location of the post office which serves the base. The distance errors inherent in these assumptions were small in comparison to the total distances being measured. The driving distances were measured rectilinearly to account for the north-south, east-west street orientation which is prevalent in most of the communities surrounding the base.

The employee's zip code was used as the basis for classification of individuals by area of residence. The zip code listed for the employee was interpreted as being his actual place of residence. The zip code from the reproduced pay records is an element of the address to which the periodic pay information is mailed and was assumed to be designated for the most expedient transmittal of pay information to the individual. The destination of the pay check was not considered important because the economic influence of the earnings is represented by the individual who has access to the money through checking accounts or other means. Mailing address zip codes that were identified in the records for areas outside of a maximum reasonable commuting distance (100 mile radius) of Wright-Patterson AFB were treated

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as anomalies in the system and their effects were summed to a dummy location with a zero distance.

Each post office was plotted on a 1:500,000 scale aeronautical chart with the aid of state and city maps and zip code and telephone area code diagrams. Measurements of distances were made by calculating differences of latitudes and longitudes to derive a set of cartesian coordinates for each post office with the origin of the coordinate system located at Building 262 on Wright-Patterson AFB. This allowed driving distances to be computed, in statute miles, by summing the absolute values of the "x" and "y" grid components associated with each zip code. Radial distances were computed by taking the square root of the sum of the squares of the "x" and "y" components.

The population of the zip code area was defined to be the number of mail delivery stops that the post office has recorded for the area multiplied by the average size of 2.97 persons per household as listed for 1974 (the most recent year) in the 1976 edition of the Statistical Abstract of the United States. Only non-commercial deliveries were considered in the determination of population by this method. The source of data for numbers of deliveries was the Directory of Post Offices, Publication 26, dated October 1976. This source contained information for all areas except those in the metropolitan regions of Dayton, Cincinnati, Springfield, and Columbus, Ohio. Data for these zip codes were obtained directly from the main post office of each city.

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The use of zip codes for determination of an individual's place
of residence was used in compiling data for the current Master Plan of
Wright-Patterson AFB. Support for this technique was also found in the
literature (3:355; 5:29).

Counties were also used as basic units (see Appendix A). The
numbers of employees for each county were determined by summing the
employees for all zip code areas whose post office was located in the
county. Population data for each Ohio county in the study were derived
from the Current Population Reports of the Bureau of the Census.
County employment statistics were obtained from the Ohio Bureau of
Employment Services. Population and employment data for counties in
Kentucky and Indiana were obtained directly from the EIFS data bank.
All data were based on estimates for 1973 except for the Ohio employ-
ment data which was current as of 31 December 1976.

The use of county units as component areas by each of the three
DoD methods of region definition causes the post office point summing
technique to have some effect of misattribution. Zip code areas are
established by postal authorities without regard to county or city
boundaries, so an employee could live in one county and his post office
could be located in another. This could only happen for those zip code
areas not wholly contained in one county; and, for a divided zip code
area, the post office has an a priori equal likelihood of being included

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in either county. The significance of this effect of misattribution is therefore considered minor.

Determination of the distance variable for each county was done in a manner similar to that described for the zip code area. The reference point for measurement of the distance to the county was the county seat. This was supported by the historic tendency to locate the county government centrally in the distribution of the population that it serves. Selection of a reference point based on land area alone would have ignored the effects of population completely, and using an effective distance derived from the average of distances weighted by the actual distribution of employees within the county would have required more data than the modeling method of region determination would warrant in actual application. The potential error in the distance as measured to the county seat is greater due to the size of the basic unit and due to the tendency of the residential distribution of employees to be somewhat skewed within the county in a direction toward the major sources of employment.

Data Collection

Information necessary to establish the place of residence and the annual gross pay for all military and civilian personnel employed at Wright-Patterson AFB was found in the master pay records maintained by the Management and Support Systems Division, Base/MAJCOM

Support Branch (ACVMS) of Air Force Logistics Command Headquarters (AFLC). Permission was obtained to duplicate the records on magnetic tape, eliminating personal information subject to the Privacy Act of 1974. Collection of data required duplication of four separate pay files stored in three different formats in the IBM B3500 computer system. These were the Air Force Logistics Command (AFLC) civilian pay file, the Aeronautical Systems Division (ASD) civilian pay file, the Non-Appropriated Fund (NAF) civilian pay file and the Military Personnel Leave and Earnings Statement files. Each of the formats required individual modifications to duplicate the desired data without extracting personal information. The AFLC and ASD files, in a 1844 character per record format, were duplicated in their entirety with blanks inserted for personal information fields. Specific fields were extracted from the NAF and Military pay files, limiting the duplicated information to non-personal data. The difference in procedure at this point in data collection was a function of the preference of the ACVMS computer programmer who furnished the services.

The timing of the files duplication was critical in capturing the end-of-year (1976) totals for pay data. The records were updated for the final pay period of the year late in December, and it was at this time that the records contained all of the required information for this study. End-of-year pay data were desired to reflect, as accurately as possible, the Wright-Patterson AFB total expenditures for Federal

wages in 1976. There were only two weeks during January when the pay records were available for duplication without interference with normal processing for pay purposes. After that time, suspense dates lapsed and parts of the files were lost. Without the necessity to capture year-end pay data, determining the number of employees and their residence locations would have been a relatively simple task and would have been possible at any specified point in time.

The pay data that were captured were slightly less than desired quality in two areas. First, the pay system for the AFLC and ASD files was implemented on 1 July 1976, collecting pay amounts for each individual and totaling pay by calendar quarters. Totals for the time preceding implementation were not entered, so the data contained only information for the last two quarters of 1976. Therefore, annual pay amounts had to be extrapolated by doubling the sum of the two quarter amounts for the AFLC and ASD files. The second source of reduced quality pay data was due to the format of the military pay files. The end-of-year totals for wages were readily available in the records, but due to the fact that non-taxable subsistence and quarters allowances are excluded from the end-of-year totals, the amounts were significantly understated for the purposes of this study. To capture both taxable and non-taxable pay, the final month (December) total entitlements amount was selected and multiplied by a factor of twelve to approximate the annual wages of each military employee. There were

no difficulties in obtaining the annual pay amounts for NAV civilian personnel.

Automatic Data Processing

The copies of the pay files were transformed during duplication from the Burroughs B3500 computer packed-data, nine-track tapes to an unpacked, seven-track form which was readable on the Honeywell 635 CREATE computer system. Translation to CREATE standard language was then required, using a standard routine developed in the AFLC CREATE software section. Each of the files were subsequently reduced by FORTRAN Y program processing to a condensed format containing only the zip code, city and state, and gross pay for each employee. All files were then merged on a single computer tape. This allowed all records to be read with single pass processing or individual files to be read for selective processing. The master pay file, in its final form, contained 28,495 military and civilian records.

A FORTRAN Y computer routine was written to read the data, sort the zip codes, and print out a listing of a complete set of zip codes and towns as recorded in the pay records (see Appendix E-1). This listing disclosed a number of errors in the recorded zip codes where there was disagreement between zip code and city. Most of these errors were made in zip codes where there was only one or two employees and were the result of simple transposition of digits in the zip code. These errors were corrected and used later to attribute

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erroneous data to their correct zip codes. Where disagreement could not be explained by the transposition of digits, the erroneous data were attributed to the zip code in the city with the largest number of employees from the base. Any time that there was disagreement between the zip code and the listed city, the city was recognized as being correct.

Initial categorization of the data by zip codes was done by using the BREAKDOWN task of the STATISTICAL PACKAGE FOR SOCIAL SCIENCES (SPSS) (Appendix E-2) from the CREATE software library (11:249). This routine was used to sum the total employment and total annual gross pay and to calculate the total employment for the base and the total Federal wages disbursed at Wright-Patterson AFB during 1976.

After correcting erroneous data discovered by the zip code and city listing, a new data file was built for 239 zip codes that were verified against their listed city for accuracy and were located within a 100 mile radius of the base. One additional zip code with a zero distance, (zip code 99999) was created to collect numbers of employees and amounts from locations greater than 100 miles. The 240 final zip codes contained the following data (see Appendix B-1):

> Sequence number
> Zip code
> Number of NAF civilian employees
> Number of Military employees
> Number of Civil Service employees
> Grid coordinate - "x" value
> Grid coordinate - "y" value

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Number of non-commercial postal deliveries
County code
Total annual Federal wages

The data were reaggregated in another file for processing based on county units. This was done by summing zip code aggregated data into their respective counties. Distances for this file were measured to the county seat. NAF and Civil Service employees were combined to indicate numbers of civilian employees. The new file excluded data for employees outside the 100 mile radius (zip code 99999), resulting in 44 counties with the following information (see Appendix B-2):

Sequence number
County code
Number of military employees
Number of civilian employees
Grid coordinate - "x" value
Grid coordinate - "y" value
Total annual Federal wages (thousands of dollars)
County population
County employment

Curve-fitting was accomplished by computer processing of the data files with the SPSS REGRESSION task (Appendix E-3) from the CREATE library (11:321). Compute commands were used to develop variables that were not explicit in the data file by factor multiplication, exponentiation, or division. The regression coefficients, the R^2 values, and the residuals analyses, were the areas of the REGRESSION program of primary interest. Since the data represented a census of the population at Wright-Patterson AFB, the statistical inference calculations were superfluous in this analysis.

Computation of mean absolute deviations (MAD) for each of the models was done in another FORTRAN Y program (Appendix E-4). The absolute values of the residuals were summed for each model that was considered. This total was divided by the number of categories involved (either zip codes or counties) to arrive at the MAD.

Evaluating DoD Methods

The first phase of this research was the evaluation of the three current methods cf defining the economic region of influence. The data from the master pay files formed a common basis upon which to evaluate each of the methods. Total employment and total gross pay for each zip code area were computed and attributed to the post office location of each employee's listed address within a 100 mile radius of the base. The actual distribution of employees and wages, determined by this method, are shown in Figures 1 and 2. This geographically referenced data was the basis used to construct an economic region of influence according to the criteria of each method. A determination of the total employment and the total wages enclosed by each method was made and compared to the total employment and wages of Wright-Patterson AFB.

In determining the number of employees enclosed by each of the methods, it was necessary to account for those employees living outside of the 100 mile radius and those military employees living in government quarters. The effects of these employees--having an indeterminable distribution in one case and a fixed identifiable location

25

For tabulated data, see
Appendix B-1.
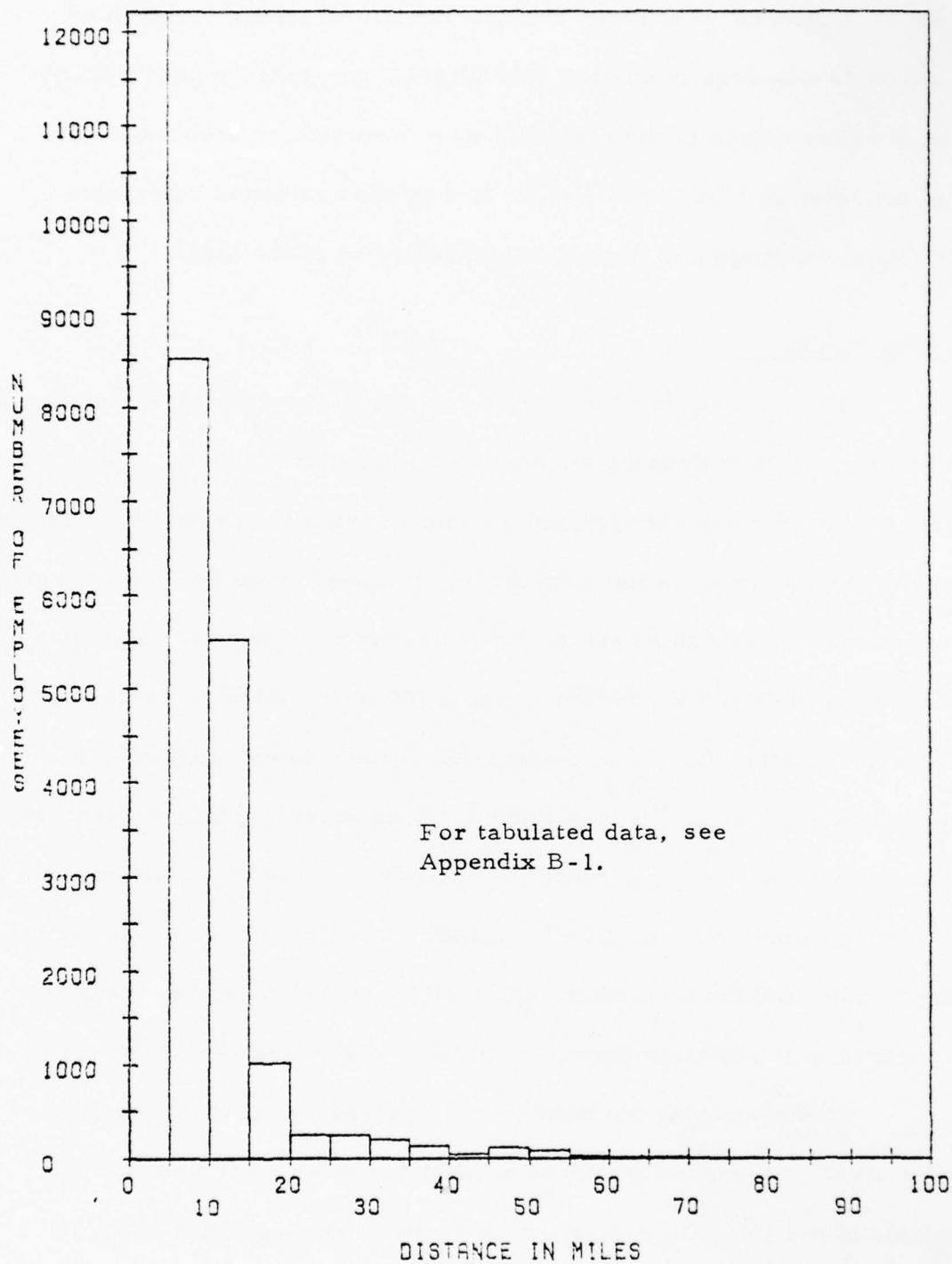
Figure 1.   Distribution of Total Employees
Radial Distance from WPAFB

26

For tabulated data, see
Appendix C-2.
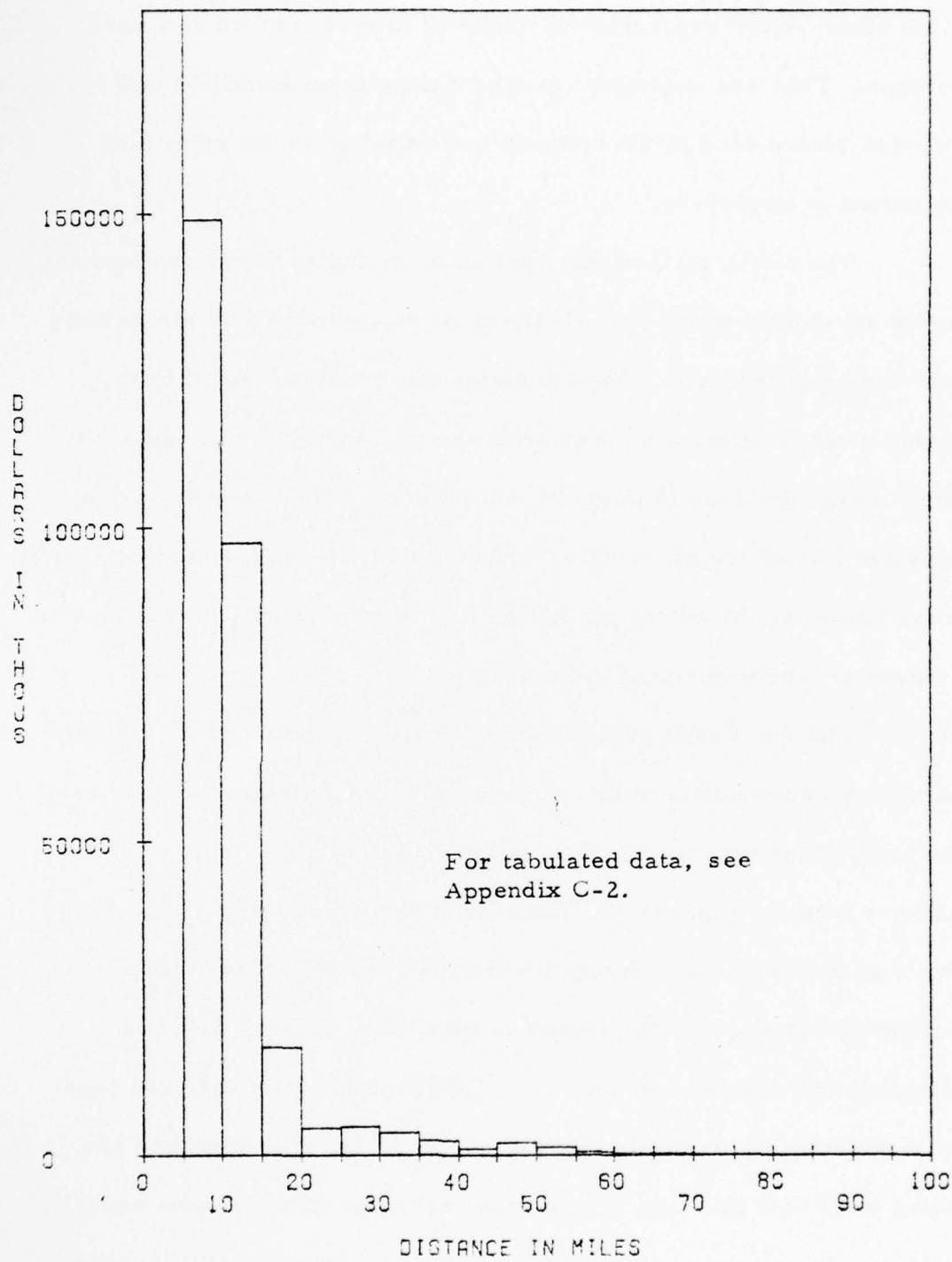
Figure 2.   Distribution of Federal Pay Radial
Distance from WPAFB

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in the other--were separated and included in each method at a zero distance. This was equivalent to considering them identified and enclosed before each of the methods were applied to the remaining population of employees.

The CERL method was applied by including within the economic region any county which was wholly or partially located within a thirty mile radius of the base. Determination was made by including the county if one or more zip codes from the county were in the data file with a radial distance of thirty miles or less. Employees and gross pay were totaled for all counties within the 30 mile radius and compared to the totals for the entire population to derive percentages for effectiveness in circumscribing the region.

The Air Force method was evaluated by including all counties containing communities within a one hour driving distance of the base. However, there was a great deal of difficulty in determining what distance actually represented a one hour driving distance. The Air Force conducted a Socio-Economic Survey (USAF SCN 76-43c) of Wright-Patterson AFB employees in July 1976. The survey was administered to a random sample of 1,865 members of the base population selected on the basis of digits in Social Security numbers and drawn from both military and civilian personnel from all base organizations. Among the questions asked was one concerning the employees' driving time to work. Results from the survey are shown in Figure 3.

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1000

750

500

250

Number of Employees

(917)

(446)

(393)

(98)

(11)

0-15   16-30   31-45   46-60   over 60
Driving Time (minutes)
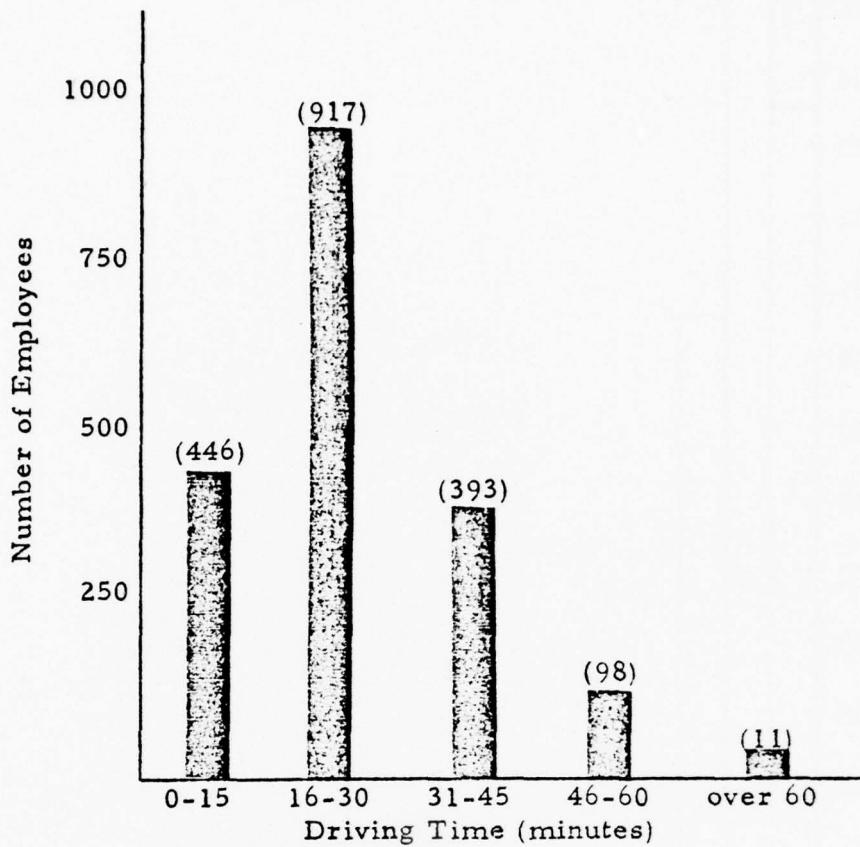
Source: USAF Socio-Economic Survey (USAF SCN 76-43c), July 1976
         1,865 respondents.

Figure 3. Distribution of Employees by Driving Time
           to Work, WPAFB, Ohio

An attempt was made to correlate the five fifteen-minute categories for

responses to the actual distribution of employees as represented by

rectilinear driving distances in Figure 4. The frequency of responses

for the "over one hour" category was so low, however, that it corres-

ponded to approximately 70 miles distance when compared with the

actual population distribution. While this was obviously erroneous as

29

For tabulated data, see Appendix C-3.
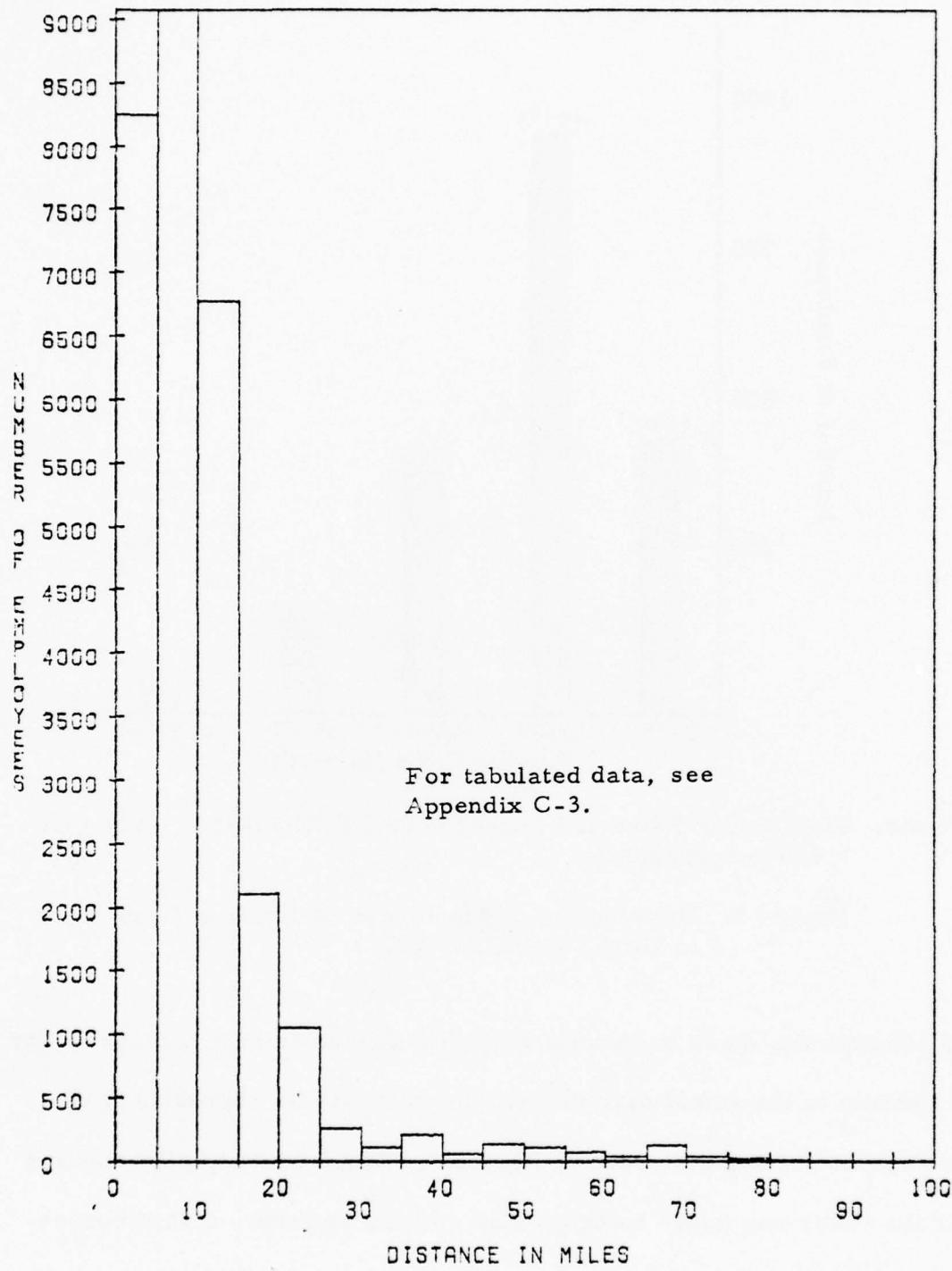
Figure 4. Distribution of Total Employees Rectilinear Distance from WPAFB

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a representation, the shape of the distribution of driving times was very similar to the distribution of the employees by rectilinear distance.

After considering the traffic conditions, the road networks, and the posted traffic speed limits around Wright-Patterson AFB, the decision was made to consider 45 miles, rectilinearly measured, representative of the distance that an employee could drive in one hour going to or from work. The total employment and total Federal wages for the base, in a rectilinear distribution, are shown in Figures 4 and 5. To evaluate the Air Force method, then, all counties within 45 miles rectilinear distance of the base were included in the economic region. The numbers of employees and their gross pay were summed within the region and compared to the total numbers and amounts for the base to derive a percentage of effectiveness.

The Army's method of defining the economic impact region was applied by identifying all counties within the data having two percent or more of their total work force employed at Wright-Patterson AFB (see Appendix D). The employment market in the local area was considered sufficiently large to eliminate any requirement to bring into consideration additional absorption job markets for the economic region (see Chapter I). For the counties identified under this method, the numbers of employees and their total pay were again totaled and compared with the totals for the base to yield percentages for effectiveness in circumscribing the area.

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For tabulated data, see
Appendix C-4.
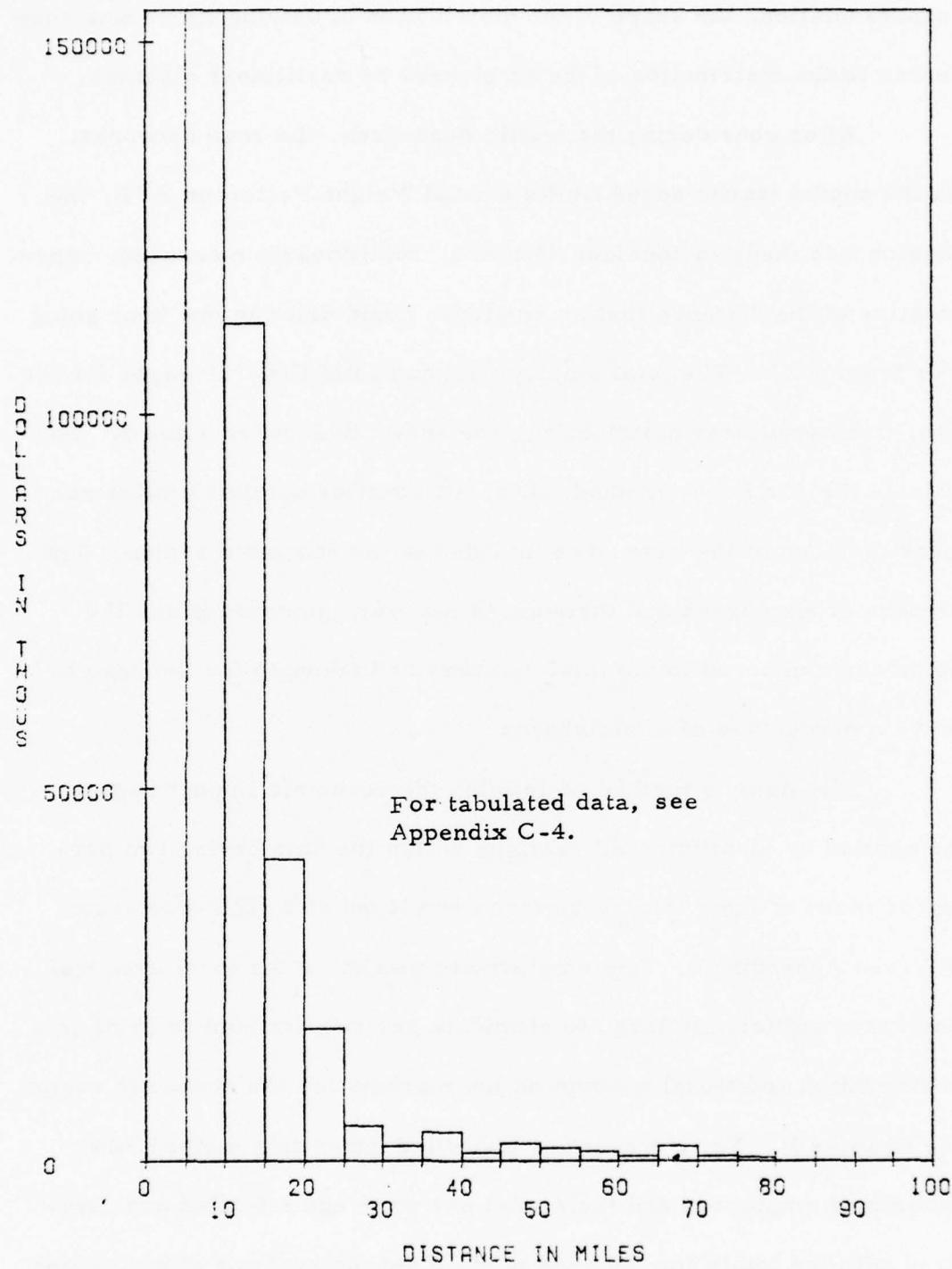
Figure 5. Distribution of Federal Pay Rectilinear
Distance from WPAFB

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After each of the three methods had been developed, they were rank ordered according to their captured percentages of the total base employment and total Federal wages. The Wright-Patterson AFB Master Plan TAB A-1 was constructed on an area including 90 percent of the base employees. For lack of a better subjective criterion, the methods were rated as "good" if they included 90 percent or more of the total employees and included 90 percent or more of the total gross pay.

A marginal analysis of the CERL method was done by examining the tabulated radial distances that brought the counties into the region. A comparison was made between the changes in the cumulative percentages of employees and of total Federal wages enclosed by the method at various radial distances. An increase in the radius without a corresponding significant improvement in the percentages served only to dilute the average economic impact potential of the military installation upon the area. An average density factor was used as an additional indicator of dilution by calculating the number of Federal employees included in the region per thousand of population. The two cumulative percentages and the density factor were graphed to show the radial distance where the CERL method began to have diminishing power in defining the region.

The Air Force method was similarly analyzed based on the change associated with the rectilinear driving distance. The changes

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in rectilinear driving distances could represent either changes in the time distance dimension of the method or they could be related to changes in the assumed average speed of 45 miles per hour attainable by the employees in driving to work in the local area. The table for this method was constructed by ordering the rectilinear distances to each community within a 100 mile radius (as indicated by the zip codes in the data) and adding counties to the region in the order that their nearest community to the base brought them into the region. Again, the cumulative percentages of employees and Federal wages included in the region and the density factor were graphed as a function of rectilinear distance to suggest the optimum distance to be used in the Air Force method of region determination.

Distance was not an independent factor for marginal analysis in the Army method; therefore, the counties were tabulated according to their percentage of total work force employed at Wright-Patterson AFB. The percentages of employees and Federal wages and the density factor were examined as a function of the threshold significant percentage of employment that would include additional counties in the region to indicate the level at which the diluting effects would occur by this method.

Evaluating Model Forms

Replacing the current methods used by DoD with a mathematical expression of employee and wage distribution has been suggested by

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CERL. If such an expression were found, impact analyses would be greatly simplified by eliminating the need to know the actual population distribution of the installation. CERL's proposed model was evaluated to determine its effectiveness in describing the distribution of the population at Wright-Patterson AFB. Variations of the gravity model form and a more common multiple variable linear form were also evaluated for their abilities to explain the relationships between the variables.

Direct evaluation of the CERL model with empirical data was impossible without knowledge of the coefficient of proportionality. Therefore, the coefficient was determined by curve fitting a linear form of the model to the data using the least-squares method.

A new independent variable, X, was formed by defining the relationship between P_j and D_{aj}:

$$X = \frac{P_j}{D_{aj}}$$

The CERL model was then written:

$$Y = kX$$

where, $Y = E_{aj}$.

The general linear model,

$$Y = b_o + b_1 X_1,$$

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would be equal to the CERL model if $b_o = 0$ and $b_1 = k$. Rather than forcing the model through the origin, however, the constant term b_o was retained to allow LSM to determine what the y-intercept should be for the Wright-Patterson AFB data. With the more general form, a better fit of the data was expected which would represent an upper bound on the performance of the CERL model.

The more common form of the gravity model of marketing theory was also analyzed by the same method after recombining the independent variables, P_j and D_{aj}, to form a new linear expression of their relationship in the data:

$$X' = \frac{P_j}{D_{aj}^2}$$

The linear form for the gravity model was then written as:

$$Y = kX'$$

Several other variants of the gravity model were analyzed in an attempt to find the best functional form. Four additional models were fitted by the least-squares method.

$$E_{aj} = k \frac{P_j}{D_{aj}^3}, \qquad E_{aj} = k \frac{P_j}{D_{aj}^4},$$

$$E_{aj} = k \frac{P_j^{1.5}}{D_{aj}}, \quad \text{and} \quad E_{aj} = k \frac{P_j^2}{D_{aj}}.$$

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The final variant of the gravity model form was analyzed by freeing the exponents of P_j and D_{aj} to assume general curve-fitting values.

$$E_{aj} = k \; \frac{(P_j^{k_1})}{D_{aj}^{k_2}} \; ,$$

where k_1 and k_2 are exponents for curve fitting by LSM. In order to use this model in a linear form, it was necessary to use a logarithmic transformation as shown below.

$$\ln E_{aj} = \ln \left[k \; \frac{(P_j^{k_1})}{D_{aj}^{k_2}} \right]$$

$$\ln E_{aj} = \ln k + \ln (P_j^{k_1}) - \ln (D_{aj}^{k_2})$$

$$\ln E_{aj} = \ln k + k_1 \ln P_j - k_2 \ln D_{aj}$$

Letting

$$Y = \ln E_{aj} \qquad\qquad b_o = \ln k$$

$$X_1 = \ln P_j \qquad\qquad b_1 = k_1$$

$$X_2 = \ln D_{aj} \qquad\qquad b_2 = -k_2$$

then,

$$Y = b_o + b_1 X_1 + b_2 X_2$$

After values were determined for b_o, b_1, and b_2 the model was

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transformed back to the original form by use of exponential functions.

The final model to be evaluated was a linear relationship for the variables:

$$E_{aj} = a + bP_j + cD_{aj}$$

where a, b, and c are coefficients for curve-fitting by LSM.

Two separate measurements were made on the models to determine their ability to predict employees in a county when the population and distance to the county were specified: the coefficient of determination (R^2) and the mean absolute deviation (MAD). The coefficient of determination is a measure of the variation of the data explained by the model (6:545). This measure of the method's success in fitting a linear model to the data is calculated by:

$$R^2 = \frac{\sum(Y_c - \overline{Y})^2}{\sum(Y - \overline{Y})^2}$$

where $\overline{Y}$ = average number of employees per area.

As the fit of the model gets better, the variation decreases and the difference between Y and Y_c approaches zero. A ratio of 1.0 indicates a perfect linear fit, while a ratio of 0. indicates that the linear model has no explanatory power for the variables in the data. R^2 was calculated for each of the models analyzed.

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The other criterion for judging the success of the model was the mean absolute deviation (MAD) between the predicted number of employees from a given area and the actual number of employees from the same area. The MAD was calculated for each model using the following expression:

$$MAD = \frac{\sum |Y_j - Y_{cj}|}{n}$$

where,

Y_j = number of employees from area j (E_{aj})

Y_{cj} = number of employees predicted from area j by the model

n = number of areas in the data

The MAD indicated the average error that could be expected in predicting the employment for any area in the region of influence using the model.

Summary of Assumptions

1. The residential distribution, wages, and general effects of service contractor employees working on the base are essentially the same as directly employed Federal workers.

2. The number of service contract workers and their total wages are small in comparison to the number and wages of all military and civilian employees.

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3. Residence locations and net pay of employees can be summed within a zip code area and attributed to the geographic location of the post office without significantly changing the distribution of employee residence or net pay.

4. The post office is the center of population for a zip code area and Building 262 is the center of employment at Wright-Patterson AFB.

5. The effect of the post office point summing techniques will cause only minor misattribution of employees and wages among counties in the universe.

6. Distribution of employee residence and wage effects by zip code areas follows the same distribution as the distribution of effects by county areas.

7. Driving distances are approximately equal to the rectilinear distances from the employees' residences to their places of work.

8. The pay information address is the actual place of residence if within a 100 mile radius of Wright-Patterson AFB.

9. The 1973 National average household size of 2.97 persons, as reported in the Statistical Abstract of the United States, defines the size of the average household in the universe of this study.

10. A rectilinearly measured distance of 45 miles is equivalent to a one hour drive in the Wright-Patterson AFB local area.

Summary of Limitations

1. The study was limited to the evaluation of various models as applied to the data at Wright-Patterson AFB, Ohio.

2. Consideration was limited to the effects of employment and Federal wage expenditures in determining the region of economic influence around Wright-Patterson AFB, Ohio.

3. The universe of the research was limited to a 100 mile radius.

CHAPTER III

RESULTS AND ANALYSIS OF DOD METHODS

Results

The first phase of this study was the evaluation of the three

primary methods of region definition currently used by DoD in economic

impact assessment and the determination of their relative successes in

circumscribing the dispersion of employees and wages in the surround-

ing communities. According to the subjective criteria established in

relation to the present Master Plan TAB A-1 economic region for the

base, all three methods were very "good." The results obtained by

each method are presented in Figure 6. The most successful method

for capturing employees and wages within the defined region was the

Air Force method. The second best method was CERL's. The Army

method resulted in the lowest percentages of employees and wages, but

it was still superior to the 90 percent criteria that is currently used.

The relative rankings of the three methods remained unchanged

whether examined on the basis of number of employees or total wages.

There' was virtually no difference between the two for a given method.

This was due to the fact that the total of the wages summed within a

county was a direct function of the number of employees residing in the

The CERL Method

Inclusion of all counties located within a distance of 30 miles resulted in the capture of:

98.71 percent of the total employees

98.78 percent of the total wages

The Air Force Method

Inclusion of all counties containing communities within one hour driving time (represented by 45 miles rectilinear distance) resulted in a region capturing:

98.94 percent of the total employees

99.01 percent of the total wages

The Army Method

Inclusion of all counties with two percent or more of the total work force employed at Wright-Patterson AFB resulted in the capture of:

94.94 percent of the total employees

94.68 percent of the total wages

Figure 6. The Region of Economic Influence, WPAFB

county. There was found to be almost no correlation between the distance from the base and the employee's annual pay (correlation coefficient = 0.18888) in an attempted curve-fit of the data.

Analysis of the Methods

There were varying degrees of difficulty in applying the methods to the data. The CERL method was the simplest, requiring only an area with a thirty mile radius to be examined. The inclusion of counties wholly or partially located at a radial distance of 30 miles from the base resulted in the inclusion of 12 counties in the region. Only the 30 mile dimension, a map showing the location of the counties and census data for the identified counties are required to apply the method.

The Air Force method was significantly more difficult to apply, requiring a knowledge of the driving times to communities throughout the area. It was necessary to either drive and time every possible branch of a large network of streets, roads, and highways or to make simplifying assumptions. Even with the simplifying assumption of considering a rectilinear distance of 45 miles being equivalent to a one hour driving distance, measurements were less conveniently made along rectilinear directions than they were by measuring radially. The region defined by the Air Force method required collection of data on 16 counties that were included in the region. This was an increase of four counties over the CERL method for an increase in effectiveness of 0.23 percent of the employees and 0.13 percent of the wages captured.

The Army method was the most difficult of all to apply, and it was the least effective. It required a complete determination of the

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actual distribution of Federal employees which would be either difficult
or impossible to attain at many DoD installations. The method also
required gathering data on the size of the work force for every county
within the 100 mile radius of the base. Once the data was gathered and
the distribution was determined, the method was easily applied by
calculating the percentage of total work force employed at Wright-
Patterson AFB for each of the counties and including within the region
those counties whose percentages were equal to or greater than two
percent. Only three counties were included using this method while
attaining an effectiveness of 94. 94 percent of employees and 94. 68 per-
cent of Federal pay. It was interesting to note that the three counties
identified by the Army method are the same three that were more
subjectively identified and included in the region specified in the Wright-
Patterson AFB Master Plan TAB A-1.

Marginal Analysis

Marginal analysis of each of the three methods was difficult due
to their rapid effectiveness in including employees and wages. After
attaining percentages of greater than 90 percent, there was limited
potential for improvement with greater distances or lower thresholds of
significant employment percentages. Therefore, the dilution effects of
introducing additional small numbers of employees at the expense of
large population increases were examined using a density factor.

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Graphs were constructed for the marginal analyses of each of these methods from data tabulated in Appendix F.

The 30 mile radius used in the CERL method could not be supported by the results of the marginal analysis. When the cumulative percentages of employees were graphed (see Figure 7) there was an almost immediate inclusion of 94.94 percent at five miles, increasing slowly and steadily as additional workers were included at greater distances. The cumulative percentages of pay were within one-tenth of a percent of the employment percentages for all distances greater than five miles. The graph of the density factor showed irregular rates of dilution as the distance was increased. After the five mile point, where the major inclusion occurred, the dilution was rather constant as the radius was increased until about 38 and 46 miles. There were rapid decreases in density at these distances due to the inclusion of Hamilton and Franklin counties, where there are high concentrations of population. Beyond 50 miles, there were no more significant changes in the rate of dilution and the density was found to slowly decline, linearly, with the radial distance. A fifty mile radius seems to be more significant in the Wright-Patterson AFB region of influence.

The one hour driving distance as represented by 45 miles rectilinear distance, seems to have some support in the plot of the density function (see Figure 8). The changes in density follow the same general patterns as they did in analysis of the CERL method

46
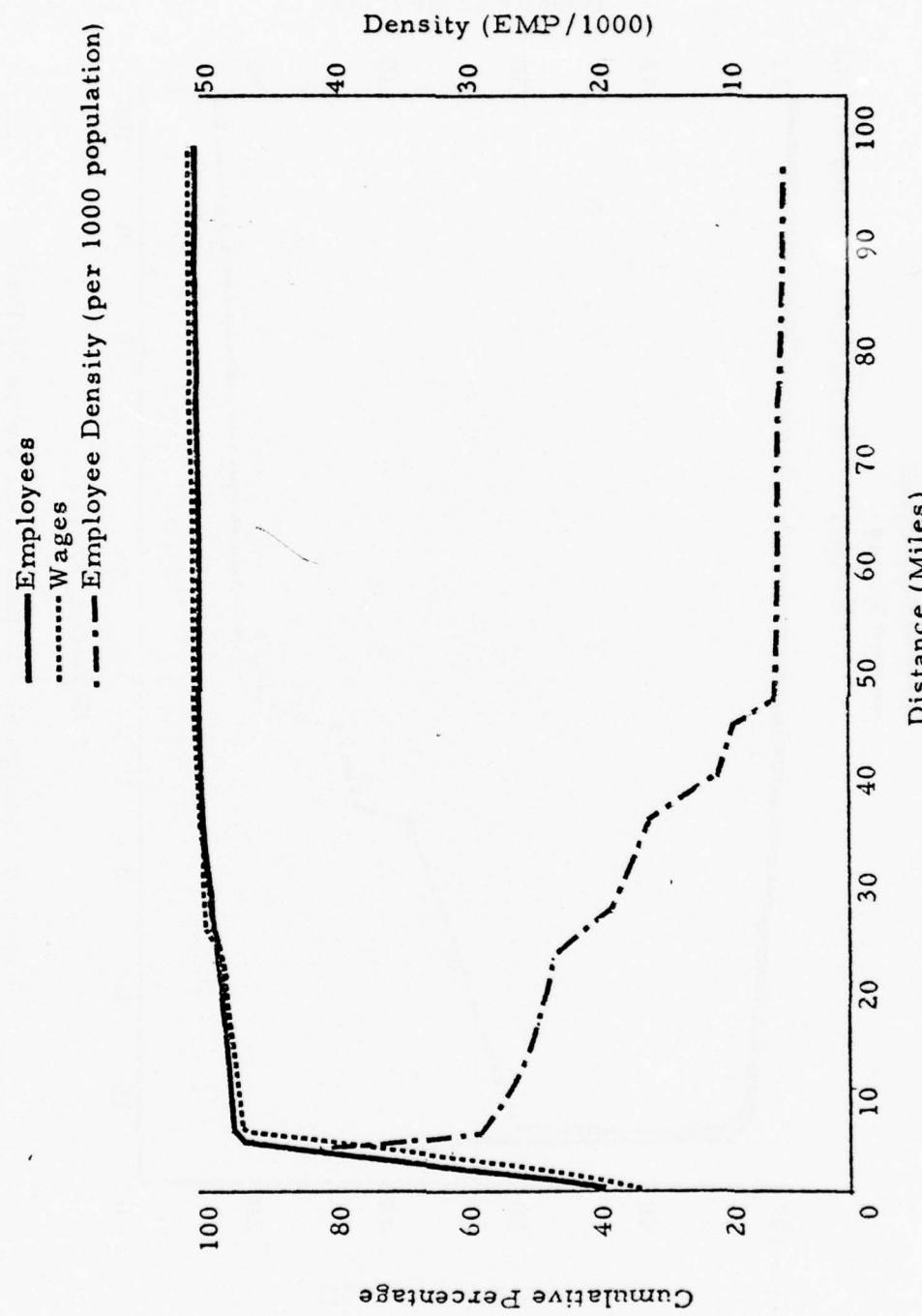
Figure 7. Marginal Analysis of CERL Method

47
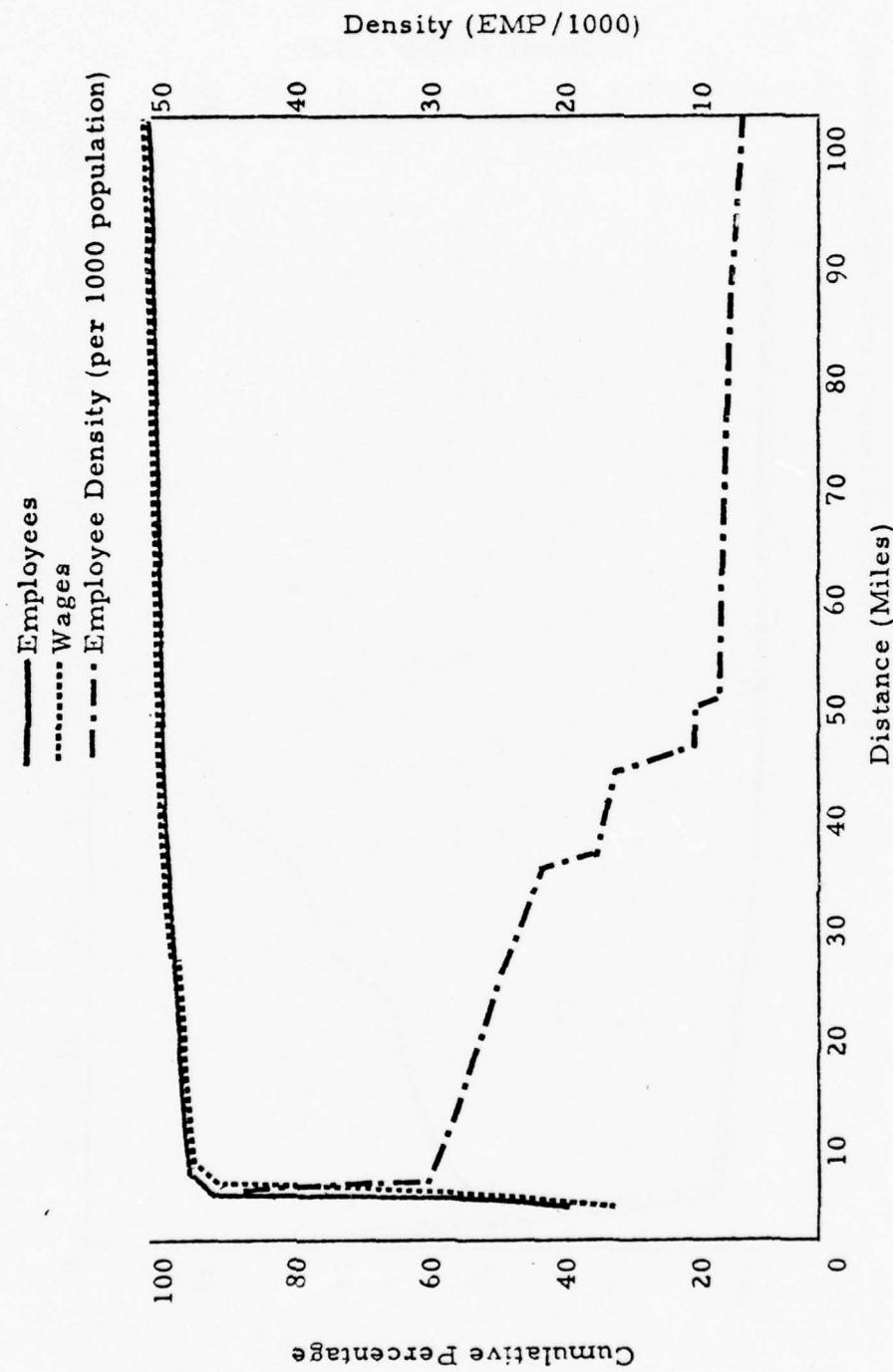
Figure 8. Marginal Analysis of Air Force Method

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where distances were computed radially; however fluctuations in the density factor, ending at about 48 miles (rectilinear) seems to signify the outer extent of the region influenced by employment (and wages) at Wright-Patterson AFB. The same effect is apparent but slightly less pronounced with distances computed radially, according to the CERL method.

Analysis of the Army method of determining the region yielded no additional meaningful information when the percentages of employees and wages and the density factor were plotted against the significance level of inclusion (see Figure 9). There were too few counties and the ranges between the actual significance levels were too widely spread to make an interpretation about support for the criterion of two percent.
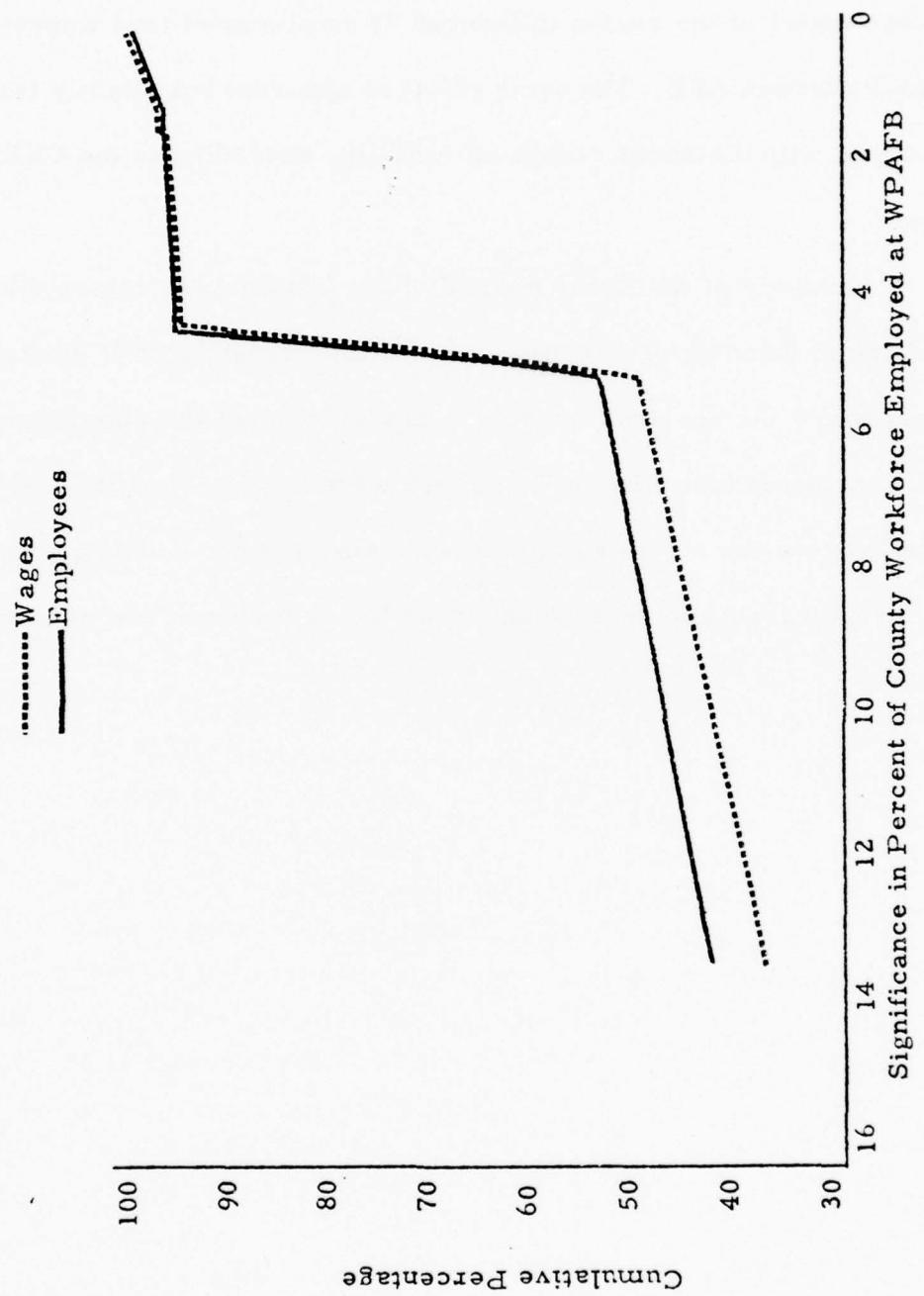
Figure 9. Marginal Analysis of Army Method

CHAPTER IV

RESULTS AND ANALYSIS OF THE MODELS

The second phase of this research was the evaluation of modeling as a method of determining the employee distribution in the region of economic influence around Wright-Patterson AFB. The proposed CERL model and seven alternative forms were evaluated. Their effectiveness in describing the relationships among the variables was measured by the associated sum of squares ratio (R^2), and their average degree of error in predicting numbers of employees was measured by the mean absolute deviation (MAD). Since the data were initially collected from the pay files by zip codes, this was the basic unit used for the first approach in developing the models. The objective was to predict the number of employees from a given zip code area by specifying the population of the zip code area and its distance from the base. The least-square models are presented in Table I. The gravity form was found to be the most effective in modeling the employee distribution. The additive model and the two models with higher order population variables showed very little potential. The best model found for this data was the log-transform model with an $R^2 = .79170$ and a MAD = 71.797. When the residuals of this model were examined for each zip

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Table I
Models Based on Data Aggregated by Zip Code

Type	Model	R^2	MAD
P/D	$E = -76.71780 + 0.29521 \left(\dfrac{P}{D}\right)$	.67895	114.050
P/D^2	$E = +35.23257 + 1.25745 \left(\dfrac{P}{D^2}\right)$	.69160	81.543
P/D^3	$E = +67.434421 + 3.90395 \left(\dfrac{P}{D^3}\right)$	.57852	106.668
P/D^4	$E = +77.86082 + 11.92591 \left(\dfrac{P}{D^4}\right)$	.51382	118.344
Log-Trans	$E = +872.7856561 \left(\dfrac{P^{0.45857}}{D^{2.41560}}\right)$	.79170	71.797
P + D	$E = +320.04671 + 0.00475\,P - 6.22287\,D$	.17177	151.179
P^2/D	$E = -14.39692 + 0.00001 \left(\dfrac{P^2}{D}\right)$	.47560	155.851
$P^{1.5}/D$	$E = -45.87819 + 0.00142 \left(\dfrac{P^{1.5}}{D}\right)$	.61147	116.652

code, several were found to be very large. One of these was zip code 45431. This zip code was found to be comprised almost entirely of military families occupying government quarters in the Page Manor area, about five miles from the base. Since information is readily available on the utilization of government family quarters and since the utilization of those quarters is not primarily a function of their attractiveness in terms of population and distance, the inclusion of these employees was considered an unnecessary demand on explaining the

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employment distribution. Therefore, the numbers of military
employees and their annual gross pay (1,436 and $1,803,931) were
deducted from zip code 45431 and combined with other military
employees residing in government quarters in the 45433 zip code.
Since 45433 was not used in the curve-fitting with a distance of zero,
all military employees living in government quarters were effectively
excluded from the data. This allowed an improved model to be
developed for determining the distribution of the remainder of the
population. Models developed with this refined data are presented in
Table II. All models except the log-transform showed significant
improvement in R^2 with the data refinement. The log-transform model
remained essentially unchanged. All MADs improved considerably.
The best model form remained the log-transform with an R^2 = .79061
and a MAD = 65.284.

CERL's proposed approach to modeling was on the basis of
the county unit, primarily because the county is the smallest unit for
which census, employment, and other statistical data are gathered.
To test the models on this basis and to compare the zip code and
county approaches, the eight models were again derived from the data
after aggregating it on a county basis. Initially, military employees
living in government quarters were attributed to the county in which
the quarters were located. The Page Manor quarters and the quarters
on the base are located in two separate counties. This convention

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Table II
Models Based on Data Aggregated by Zip Code--
Military in Government Quarters Excluded

Type	Model	R^2	MAD
P/D	$E = -71.83004 + 0.27877\left(\dfrac{P}{D}\right)$	.70114	105.053
P/D^2	$E = +33.16053 + 1.19721\left(\dfrac{P}{D^2}\right)$	.73057	73.803
P/D^3	$E = +63.07416 + 3.76526\left(\dfrac{P}{D^3}\right)$	.63146	97.660
P/D^4	$E = +72.63598 + 11.65181\left(\dfrac{P}{D^4}\right)$	.57715	108.764
Log-Trans	$E = +854.32356\left(\dfrac{P^{0.45687}}{D^{2.40627}}\right)$	.79061	65.284
P + D	$E = +299.27961 + 0.00446\,P$ $-5.81064\,D$	.17651	138.832
P^2/D	$E = -14.27528 + 0.00001\left(\dfrac{P^2}{D}\right)$	.50609	151.303
$P^{1.5}/D$	$E = -43.53670 + 0.00135\left(\dfrac{P^{1.5}}{D}\right)$	.64144	108.621

resulted in the models in Table III. Applying the concept developed in the zip code approach, all military employees living in government quarters were considered identifiable and were not required to be involved in a prediction of employee distributions. Their numbers and wage effects were deducted from the affected counties (Greene--2098 and $23,876,442, Montgomery--1436 and $11,282,728) and the models

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Table III
Models Based on Data Aggregated by County

Type	Model	R^2	MAD
P/D	$E = -242.99404 + 0.31406 \left(\dfrac{P}{D}\right)$	.74563	470.338
P/D^2	$E = +31.02612 + 5.09689 \left(\dfrac{P}{D^2}\right)$	.86697	289.397
P/D^3	$E = +127.44225 + 73.5346 \left(\dfrac{P}{D^3}\right)$	.87025	302.618
P/D^4	$E = +160.89967 + 1057.0989 \left(\dfrac{P}{D^4}\right)$	.86586	318.800
Log-Trans	$E = +22437.75 \left(\dfrac{P^{0.75091}}{D^{3.84564}}\right)$	.88207	195.408
P + D	$E = +2566.86681 + 0.00357\ P\ -33.23716\ D$	.28990	1200.614
P^2/D	$E = +128.481 + 0.0 \left(\dfrac{P^2}{D}\right)$	.52189	672.578
$P^{1.5}/D$	$E = +23.47851 + 0.00036 \left(\dfrac{P^{1.5}}{D}\right)$	.61895	527.971

were again developed from the refined data. The results are shown in

Table IV. The models all showed improvement in the MADs and R^2

values with the exception, again, of the log-transform which remained

essentially unchanged. The best model for the county unit approach

was still the log-transform type, although superiority is not shown in

the evaluation by R^2. The values of R^2 for the D^2, D^3, and D^4 models

were all higher, but by only a very small amount. The MADs, however

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Table IV
Models Based on Data Aggregated by County--
Military in Government Quarters Excluded

Type	Model	R^2	MAD
P/D	$E = -226.29489 + 0.27841 \left(\dfrac{P}{D}\right)$	.78583	405.396
P/D^2	$E = +18.03976 + 4.50593 \left(\dfrac{P}{D^2}\right)$	.90869	226.061
P/D^3	$E = +103.82833 + 64.92494 \left(\dfrac{P}{D^3}\right)$	.90978	236.853
P/D^4	$E = +133.69176 + 932.57241 \left(\dfrac{P}{D^4}\right)$	.90372	251.190
Log-Trans	$E = +19820.46 \left(\dfrac{P^{0.74531}}{D^{3.80292}}\right)$	.88040	160.058
P + D	$E = +2192.96582 + 0.00323 \, P$ $-28.55624 \, D$	.29765	1032.235
P^2/D	$E = +98.60682 + 0.0 \left(\dfrac{P^2}{D}\right)$	.56140	572.682
$P^{1.5}/D$	$E = +6.43192 + 0.00032 \left(\dfrac{P^{1.5}}{D}\right)$	.66110	442.330

were significantly different with the log-transform model being 60
employees per county more accurate, on the average, than the second
best model.

The county approach was shown to be superior to the zip code
approach in both the R^2 and the MAD criteria. The values of R^2 were
lower for all models when the data were aggregated on the basis of the
larger county units. In spite of higher MADs in models with county

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aggregated data, the deviations were better when the county's average

number of base employees were considered. The county's average of

647.6 employees was more than five times the zip code area's average

of 118.7.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The Method of Identifying the Region

The National Environmental Policy Act requires that prior to any decisions on Federal activities or programs, agency officials shall carefully and thoroughly assess possible consequences to the environment. The purpose of this research was to evaluate the methods of determining the regions of economic influence around a military installation. Fundamental to an analysis of possible consequences is the identification of the regions influenced.

Three different methods for determining the region of economic influence around a military installation were identified for use by the Department of Defense. This indicated that a community's economic consideration in installation realignments or program changes was largely dependent on which agency of the DoD is "carefully and thoroughly assessing the possible consequences [16]." All three of the methods performed satisfactorily in identifying regions around Wright-Patterson AFB containing more than 90 percent of the total employees and wages. The CERL method was the most effective, however, for the amount of effort required to apply it. With a fixed radius of 30

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miles, it enclosed 98.71 percent of the total employees and 98.78 percent of the total wages. This suggests that a region of influence can be established by including all counties within a specified distance from the installation. For Wright-Patterson AFB, the Air Force method's marginal analysis suggests that a 50 mile rectilinear distance might be the most appropriate.

In comparing the results of the three methods and in attempting to explain the differences in the areas that they enclosed, it became apparent that the objectives of the Army method were not the same as those of the other two but concerned the direct determination of the region of significant impact. It had subjectively decided upon the two percent level of significance before attempting to identify the region of influence. The lack of standard guidance within DoD permits each agency to make its own interpretation of the degree of influence contained within the region that it identifies. To comply with NEPA in any thorough assessment, it seems necessary to identify the entire region that is influenced by the military installation. The CERL method and the Air Force method appear to be designed for this purpose.

Surprisingly, the study of wages in the determination of a region of economic influence resulted in compounding the difficulty of gathering and processing data without adding to the meaningfulness of the results. Gaining specific data on the distribution of pay closely parallels the border of an area protected by the Federal Privacy Act.

This does not make the information inaccessible, but it does make it much more sensitive until it is aggregated into larger categories. Marginal analysis of each method showed that the percentage of employees identified was virtually equivalent to the percentage of pay included for a corresponding distance. The total Federal wages contained in a county or zip code area was directly related to the number of employees living there. A low correlation coefficient demonstrated the lack of a strong linear relationship between the employee's annual pay and the distance that he lives from the installation. Concentration on finding the region of influence by locating the residences of the employees greatly simplifies the procedures and could result in the development of sources of data, other than pay records, for DoD studies.

Modeling the Region

The result of this study indicated that mathematical modeling of employee distributions at military installations is quite feasible where the actual distributions cannot be determined by other means. The gravity form for the model was better than the additive form in every situation evaluated. As expected, the most effective model was the log-transform version. Using this model with data aggregated by county and excluding military employees in government quarters, an R^2 of .88040 and a MAD of 160.058 were obtained. Since the exponents of the variables in the log-transform model were considerably different

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from the first order of the variables as used by CERL, and since the log-transform model performed better than the CERL model at Wright-Patterson AFB, it is felt that an improved version of the gravity model might be developed for broad applications. Additional research is needed, however, before a single best model can be constructed for use at a wide variety of installations.

The methodology used in the modeling phase of this research indicated that the county unit basis was more effective than the zip code basis. R^2 increased (or remained essentially unchanged) and the MAD decreased in the aggregation of the larger units. Evaluation on the county basis was much easier to perform due to the fact that data were more readily available in Government statistical sources. The volume of data required was smaller since there were fewer units with which to be concerned. Finally, the county was better able to absorb variations due to extraneous factors because of its larger size. The measurement of distances to the counties was done by use of the county seat as a reference point. Ease of determination was a factor, but the use of this point seemed to be an objective consideration of both the area and population distributions of the county in predictions of employee attraction.

The results of refining the data by removing military employees residing in government quarters demonstrated that modeling should be reserved for determination of distributions that cannot be

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otherwise determined. Actual data in the records associated with the administration of government quarters make the residential distribution of a portion of the installation's employees immediately identifiable. Refinement of the data to take advantage of this fact improves the model's overall performance.

Recommendations

1. The region of economic influence should be determined solely by the distribution of employees. Consideration of wages in the study compounds the difficulty of gathering data without adding to the meaningfulness of the results.

2. Actual data should be used, whenever available, to determine the distribution of employees. If the use of a model is required to estimate the distribution, employees in government quarters should be excluded from the estimated portion of the population to improve the effectiveness of the model.

3. The county should continue to be used as the basic unit of area in mathematical modeling of employee distributions. The broader categorization of data dampened local variations that appeared within the zip codes and resulted in better values of R^2 for all the models investigated.

4. CERL should evaluate employee distributions at other installations with the log-transform model and should statistically estimate the parameters to be used in a gravity model. Additional

research is required to determine the applicability of a single model to employee distributions at installations of differing sizes.

5.   Until suitable models are developed for estimation of the employee distribution, the CERL method of determining the region of economic influence by specifying a radial distance should be used when actual data are not available.   The radius to be used may be variable, from 30 miles suggested by CERL to 50 miles suggested by the distribution of employees at Wright-Patterson AFB, dependent on the size of the installation.

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APPENDIX A

COUNTIES IN THE RESEARCH POPULATION

1	ADAMS
2	ALLEN
6	AUGLAIZE
8	BROWN
9	BUTLER
11	CHAMPAIGN
12	CLARK
13	CLERMONT
14	CLINTON
17	CRAWFORD
19	DARKE
21	DELAWARE
23	FAIRFIELD
24	FAYETTE
25	FRANKLIN
29	GREENE
31	HAMILTON
32	HANCOCK
33	HARDIN
36	HIGHLAND
40	JACKSON
42	KNOX
45	LICKING
46	LOGAN
49	MADISON
51	MARION
55	MIAMI
57	MONTGOMERY
65	PICKAWAY
68	PREBLE
69	PUTNAM
71	ROSS
73	SCIOTO
75	SHELBY
80	UNION
81	VAN WERT
83	WARREN
101	BOONE, KY
102	CAMPBELL, KY
103	KENTON, KY
104	DEARBORN, IN
105	HENRY, IN
106	RANDOLPH, IN
107	WAYNE, IN

APPENDIX B

DATA

1. "DATAZ" FILE: DATA AGGREGATED BY ZIP CODE

10	41015	0	2	8	-25.9	-50.4	42102	103	137.886
20	41042	0	0	1	-30.7	-55.0	6772	101	23.607
30	41071	0	0	5	-22.2	-49.1	23137	102	75.841
40	43009	0	0	4	22.4	25.8	44	11	76.276
50	43010	0	0	1	23.3	13.7	108	12	4.513
60	43015	0	1	0	52.1	34.3	8706	21	30.513
70	43021	0	1	0	8.8	29.0	1900	21	5.010
80	43029	0	0	1	29.5	22.2	155	30	21.732
90	43040	0	0	2	36.2	30.0	5051	80	23.974
100	43044	0	1	11	25.7	19.0	1510	11	229.585
110	43045	0	0	1	32.6	26.1	485	80	8.614
120	43050	0	0	1	83.1	40.7	9425	42	21.782
130	43055	0	0	1	84.5	16.1	24156	45	7.564
140	43060	0	1	1	26.2	29.1	579	11	26.960
150	43065	0	0	1	51.4	24.7	1061	21	0.733
160	43068	0	0	4	66.6	10.8	7548	25	30.392
170	43072	2	0	52	4.6	22.6	1471	11	1051.767
180	43078	0	1	64	15.7	21.6	6713	11	1184.176
190	43081	0	1	1	60.0	22.4	9497	25	32.438
200	43085	0	0	1	52.8	19.9	8568	25	0.964
210	43106	0	0	1	35.2	-13.5	383	24	22.087
220	43110	0	1	0	22.0	-59.2	1945	25	9.122
230	43113	0	0	1	59.9	-14.0	608	65	6.699
240	43123	0	1	0	46.4	3.7	8523	25	10.148
250	43125	0	0	1	62.7	3.5	2155	25	2.692
260	43128	0	0	17	26.1	-10.0	796	24	253.093
270	43130	0	0	2	78.0	-6.2	17430	23	8.359
280	43140	0	2	16	32.6	5.9	4872	49	314.815
290	43145	0	0	1	42.8	-17.0	608	65	11.222
300	43147	0	0	1	69.7	5.8	1704	23	10.529
310	43153	0	0	2	23.6	-4.1	409	49	24.998
320	43160	0	0	25	32.6	-18.2	7445	24	376.128
330	43201	1	0	1	57.4	12.1	17885	25	4.901
340	43202	0	0	3	50.3	18.2	10613	25	24.458
350	43204	0	0	1	55.2	10.9	15457	25	15.635
360	43205	1	0	0	58.3	11.4	9663	25	0.
370	43206	0	0	1	56.5	10.1	12523	25	2.832
380	43207	0	0	2	58.3	11.4	15950	25	33.281
390	43209	0	0	4	58.3	11.4	12652	25	48.972
400	43210	0	0	2	57.2	11.7	818	25	2.889
410	43212	0	0	2	54.6	11.7	10351	25	42.459
420	43213	0	0	2	60.3	11.5	12853	25	33.458
430	43214	0	1	0	50.3	18.2	12570	25	30.753
440	43219	0	0	1	60.3	11.5	9602	25	10.357
450	43220	0	0	2	54.1	18.9	11934	25	38.016
460	43221	0	0	2	52.8	19.9	9684	25	16.725
470	43223	0	0	1	49.0	1.8	14479	25	9.994
480	43227	0	0	5	64.7	10.8	23837	25	51.204

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490	43228	0	0	1	58.0	9.7	12589	25	30.106
500	43229	0	1	2	56.3	19.0	21797	25	66.132
510	43230	0	0	1	62.8	16.2	6411	25	30.566
520	43302	0	0	1	43.4	54.6	20367	51	12.115
530	43311	0	3	9	15.5	38.4	6482	46	172.994
540	43318	0	0	5	7.2	35.1	946	46	108.099
550	43324	0	0	4	13.0	44.1	968	46	76.956
560	43326	0	0	1	23.3	58.6	5351	33	23.397
570	43331	1	1	2	6.7	47.0	1945	46	51.531
580	43343	0	0	4	4.0	34.2	409	46	66.545
590	43347	0	0	1	20.0	45.6	380	46	17.157
600	43348	1	0	4	8.1	46.0	619	46	55.905
610	43357	0	0	4	15.9	31.3	1174	46	79.950
620	43360	0	0	1	19.7	37.2	316	46	0.556
630	44820	0	0	1	57.0	69.6	7307	17	7.731
640	45003	0	0	1	-41.1	-15.9	597	9	27.706
650	45005	1	3	33	-13.3	-16.3	8965	83	610.452
660	45011	0	6	14	-27.5	-28.2	40236	9	377.186
670	45030	0	0	3	-41.1	-37.1	4210	31	65.937
680	45032	0	0	1	2.1	-20.5	155	83	8.160
690	45036	0	0	20	-8.6	-25.3	5043	83	368.122
700	45040	0	2	4	-14.0	-30.5	2316	83	105.890
710	45042	0	4	46	-16.5	-20.7	24952	9	922.828
720	45054	0	0	3	-2.5	-24.2	378	83	69.451
730	45056	0	9	2	-37.0	-20.3	5770	9	179.615
740	45065	0	0	2	-3.9	-31.0	1010	83	26.222
750	45066	0	2	12	-9.7	-17.3	1444	83	258.360
760	45067	0	0	1	-21.6	-21.9	2421	9	16.939
770	45068	0	1	28	-6.5	-18.5	1734	83	427.954
780	45069	0	4	9	-19.1	-34.0	4020	9	221.708
790	45102	0	0	1	-9.0	-53.1	2383	13	23.397
800	45103	0	0	3	-7.0	-49.7	4570	13	33.361
810	45107	0	1	10	3.4	-35.1	2420	14	178.327
820	45113	0	0	8	3.8	-27.6	644	14	128.062
830	45121	0	0	1	8.1	-64.7	2272	8	7.632
840	45122	0	0	3	-5.9	-39.1	2414	13	73.410
850	45123	0	0	5	35.6	-31.2	3272	36	82.963
860	45133	0	1	13	23.5	-41.4	5637	36	217.466
870	45135	0	0	7	26.3	-31.5	937	36	96.615
880	45140	0	1	1	-9.7	-36.8	6660	31	61.683
890	45142	0	0	8	14.0	-38.4	1112	36	126.476
900	45146	0	1	8	13.0	-32.6	406	14	138.231
910	45150	0	4	1	-13.2	-43.4	5997	13	111.673
920	45152	0	1	3	-4.4	-30.8	1876	83	50.929
930	45159	0	0	6	19.1	-32.8	901	14	82.232
940	45164	0	0	1	14.5	-16.8	121	14	12.822
950	45169	0	2	17	22.4	-21.9	1769	14	314.175
960	45171	0	0	1	13.0	-54.6	1184	8	7.165

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970	45172	0	0	1	33.5	-50.4	75	36	23.888
980	45177	0	1	107	21.1	-24.7	6122	14	1797.675
990	45201	0	1	2	-24.6	-48.0	3000	31	58.959
1000	45202	0	2	0	-24.6	-48.0	4580	31	18.601
1010	45204	0	0	1	-24.6	-48.0	4142	31	24.425
1020	45205	0	0	5	-24.6	-48.0	9497	31	67.751
1030	45206	0	0	1	-23.1	-47.0	8520	31	15.336
1040	45208	0	0	1	-21.5	-46.6	9011	31	11.285
1050	45209	0	0	1	-21.5	-46.6	5954	31	9.866
1060	45210	0	0	1	-24.6	-48.0	6489	31	0.037
1070	45211	0	1	4	-24.9	-46.2	23160	31	87.551
1080	45212	0	1	2	-21.2	-44.4	11994	31	31.916
1090	45213	0	0	1	-16.4	-42.0	5591	31	24.619
1100	45214	0	0	1	-24.6	-48.0	7754	31	8.348
1110	45215	0	0	13	-22.0	-44.1	1325	31	202.696
1120	45216	0	1	1	-22.0	-43.1	4722	31	42.969
1130	45218	0	0	1	-23.5	-42.8	1892	31	0.
1140	45219	0	0	5	-23.1	-47.0	8909	31	35.791
1150	45220	0	0	5	-23.1	-47.0	7781	31	60.117
1160	45223	0	1	1	-25.0	-45.6	7400	31	27.333
1170	45224	0	1	2	-25.0	-45.6	9203	31	49.086
1180	45225	0	0	1	-25.0	-45.6	6102	31	0.043
1190	45226	0	0	2	-21.2	-47.2	3652	31	31.904
1200	45227	0	0	6	-17.0	-44.0	9462	31	93.856
1210	45229	0	0	4	-23.1	-47.0	9272	31	49.070
1220	45230	0	2	2	-19.7	-46.6	13619	31	90.987
1230	45231	0	3	7	-24.9	-44.7	15834	31	192.365
1240	45236	0	0	9	-16.4	-42.0	11398	31	184.985
1250	45238	0	0	1	-25.8	-47.9	19513	31	17.800
1260	45239	0	4	10	-24.9	-44.7	20419	31	170.232
1270	45240	0	6	18	-23.5	-42.3	9230	31	407.812
1280	45241	0	1	7	-20.6	-42.8	6041	31	179.615
1290	45242	0	0	1	-16.4	-42.0	8045	31	21.749
1300	45243	0	0	4	-17.0	-44.0	5377	31	68.661
1310	45244	0	0	1	-17.0	-44.0	5918	31	16.256
1320	45246	0	1	5	-23.5	-42.8	3402	31	113.374
1330	45301	0	1	8	1.3	-6.7	130	29	164.458
1340	45303	0	0	2	-31.4	28.4	814	19	42.625
1350	45304	0	0	18	-26.7	12.9	2337	19	358.249
1360	45305	2	20	106	-2.5	-11.5	2074	29	2449.891
1370	45307	0	1	8	21.6	-14.8	138	29	139.087
1380	45308	0	1	1	-19.9	22.6	1585	55	36.471
1390	45309	0	2	33	-19.3	2.5	3469	57	610.105
1400	45311	0	0	2	-32.4	-11.7	1741	68	35.464
1410	45312	0	1	7	-4.1	17.5	372	55	186.237
1420	45314	0	0	31	13.0	-4.1	699	29	531.470
1430	45315	0	1	12	-16.3	4.4	725	57	284.893
1440	45316	1	0	6	12.4	0.	91	29	106.971

1450	45317	0	1	7	-4.5	23.3	341	55	148.968
1460	45318	0	0	9	-15.7	22.1	1962	55	168.511
1470	45319	1	0	7	5.9	6.9	117	12	104.350
1480	45320	0	2	12	-31.3	-3.5	3819	68	269.043
1490	45322	1	7	149	-13.1	4.7	6690	57	2903.859
1500	45323	19	83	467	6.3	6.6	2035	12	10192.012
1510	45324	393	1261	2639	2.0	1.2	13347	29	68712.306
1520	45326	0	0	1	-3.3	23.6	380	55	20.381
1530	45327	2	1	13	-16.8	-12.1	3683	57	249.422
1540	45328	0	0	2	-23.6	21.9	183	19	14.094
1550	45331	0	0	24	-30.9	21.5	8095	19	417.641
1560	45332	0	0	1	-39.2	13.8	109	19	24.253
1570	45335	1	1	53	17.6	-9.8	1771	29	968.329
1580	45337	0	0	3	-19.2	13.6	609	55	46.902
1590	45338	0	1	10	-26.2	3.5	1414	68	195.713
1600	45339	0	2	7	-15.5	13.8	1186	55	131.688
1610	45341	15	29	224	0.6	5.0	1628	12	4401.046
1620	45342	0	5	56	-10.0	-10.5	7416	57	981.354
1630	45344	44	88	632	1.3	9.2	5968	12	12787.985
1640	45345	0	1	18	-19.5	-15.0	2473	57	263.676
1650	45346	0	0	6	-8.1	12.1	1008	19	84.455
1660	45349	0	0	12	6.1	13.1	175	12	238.343
1670	45350	0	0	1	-27.5	36.0	52	19	17.720
1680	45352	0	0	1	-36.2	17.5	86	19	8.702
1690	45356	1	2	34	-10.1	24.2	9647	55	636.742
1700	45358	0	0	3	-23.1	13.0	136	19	60.235
1710	45359	0	0	2	-15.5	17.6	371	55	32.342
1720	45363	0	0	1	-18.3	30.6	110	75	26.429
1730	45365	0	1	9	-10.4	33.4	9000	75	175.050
1740	45368	0	0	17	22.5	1.7	1333	12	265.253
1750	45369	0	2	12	23.7	6.9	832	12	176.960
1760	45370	1	4	24	2.1	-12.9	766	29	496.927
1770	45371	1	8	180	1.2	-6.8	4344	55	3636.583
1780	45372	0	0	2	11.6	15.0	139	12	37.263
1790	45373	2	17	84	-7.8	16.1	9752	55	1629.793
1800	45377	2	11	138	-7.9	6.3	4725	57	2760.031
1810	45378	0	0	1	-23.7	7.5	211	68	24.992
1820	45380	1	1	4	-22.6	29.1	1701	19	78.574
1830	45381	2	2	6	-25.8	-4.0	1828	68	122.001
1840	45382	0	0	1	-31.1	7.1	632	68	7.473
1850	45383	1	2	27	-15.0	11.3	2535	55	580.371
1860	45384	0	1	25	9.3	-5.5	360	29	539.570
1870	45385	21	271	1124	6.4	-8.1	14276	29	27033.416
1880	45387	6	11	174	8.6	0.3	2234	29	3465.220
1890	45389	0	1	7	-11.3	17.8	237	11	151.337
1900	45402	2	1	34	-3.1	-3.2	1738	57	587.271
1910	45403	15	32	225	-6.9	-3.2	9529	57	3812.003
1920	45404	8	38	112	-6.7	-1.5	6901	57	1980.100

1930	45405	7	32	255	-8.6	-0.2	14309	57	4601.636
1940	45406	32	31	574	-9.3	-3.1	14578	57	9583.738
1950	45407	33	4	320	-9.2	-3.7	8571	57	4221.486
1960	45408	38	3	358	-11.4	-3.1	6654	57	4790.702
1970	45409	2	11	64	-6.1	-5.2	4362	57	1302.196
1980	45410	9	15	172	-3.1	-3.2	9312	57	2947.007
1990	45414	4	21	204	-7.7	1.4	8529	57	3887.166
2000	45415	3	24	193	-8.6	-0.2	4496	57	4175.653
2010	45416	0	4	90	-14.0	-0.2	2697	57	1448.811
2020	45417	31	2	416	-11.3	-3.1	6308	57	5955.432
2030	45418	14	6	252	-11.3	-3.1	2043	57	4217.605
2040	45419	4	13	205	-6.1	-5.2	7522	57	4345.056
2050	45420	7	13	355	-4.5	-4.5	12248	57	6302.425
2060	45424	38	1170	1659	-6.7	-1.5	13119	57	55390.527
2070	45426	0	14	172	-14.0	-0.2	6326	57	3555.850
2080	45427	15	3	181	-11.3	-3.1	5316	57	2790.798
2090	45429	7	36	464	-5.8	-5.1	10835	57	9831.422
2100	45430	2	47	194	-4.5	-4.5	1660	57	4908.079
2110	45431	134	1798	930	-3.3	-2.2	8232	57	42055.338
2120	45432	19	217	594	-3.3	-2.2	5859	57	15792.606
2130	45433	74	2098	202	0.	0.	2827	29	31835.268
2140	45439	2	3	42	-10.6	-8.6	4303	57	701.750
2150	45440	1	68	495	-4.7	-11.0	6225	57	11658.594
2160	45449	2	12	100	-10.6	-3.6	6664	57	1958.434
2170	45459	2	37	353	-4.7	-11.0	10511	57	8534.357
2180	45501	7	39	255	12.3	6.9	1192	12	5401.257
2190	45503	6	9	271	14.5	10.4	11317	12	4820.910
2200	45504	3	6	235	12.1	9.8	7550	12	4286.894
2210	45505	11	5	243	15.7	8.1	10853	12	4071.592
2220	45506	27	8	460	11.7	6.7	8021	12	8323.879
2230	45601	0	0	2	58.3	-32.2	16471	71	16.235
2240	45633	0	0	1	65.7	-24.6	63	71	0.655
2250	45662	0	0	1	63.2	-71.8	18596	73	11.927
2260	45679	0	0	1	26.1	-59.4	694	1	12.446
2270	45692	0	1	0	81.0	-47.2	3558	40	11.249
2280	45805	0	0	2	-2.8	64.9	34027	2	32.218
2290	45840	0	2	1	21.5	36.0	17029	32	52.069
2300	45865	0	0	2	-17.3	40.7	1485	6	35.386
2310	45875	0	0	2	-3.0	84.3	2664	69	24.665
2320	45885	0	0	1	-17.8	51.2	4048	6	21.729
2330	45891	0	0	1	-28.4	73.7	6175	81	3.956
2340	47018	0	0	1	-54.2	-53.9	1009	104	27.459
2350	47025	0	0	1	-43.2	-43.9	3970	104	19.762
2360	47335	0	0	1	-61.9	0.6	345	107	3.390
2370	47355	0	0	1	-46.6	17.0	1010	106	25.029
2380	47362	0	0	2	-69.8	8.5	12379	105	14.880
2390	47374	0	1	7	-45.3	1.5	20106	107	148.530
2400	99999	33	243	1302	0.0	0.0	88888	999	20687.449

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2. "DATAC" FILE: DATA AGGREGATED BY COUNTY

10	1	0	1	27.6	-69.5	12.446	21100	5431
20	2	0	2	-2.8	64.9	32.218	109700	46563
30	6	0	3	-7.8	52.9	57.115	40300	16448
40	8	0	2	8.1	-64.7	14.797	28800	11029
50	9	23	73	-27.5	-23.2	1745.982	237600	93658
60	11	4	141	15.7	21.6	2720.101	30900	12567
70	12	269	2971	11.7	6.7	55112.262	157500	61096
80	13	4	8	-7.0	-49.7	241.341	102100	35657
90	14	5	157	21.1	-24.7	2651.524	32200	14191
100	17	0	1	57.0	69.6	7.781	51600	20531
110	19	1	63	-30.9	21.5	1106.548	50900	24170
120	21	2	1	52.1	34.3	36.556	47100	19857
130	23	0	3	78.0	-6.2	18.888	78800	31667
140	24	0	43	32.6	-18.2	651.313	26800	10826
150	25	5	42	60.3	11.5	533.544	856900	391483
160	29	3669	4904	6.4	-8.1	136442.912	126500	46804
170	31	26	130	-24.6	-43.0	2543.820	907400	363012
180	32	2	1	21.5	36.0	52.069	62700	27111
190	33	0	1	23.3	53.6	23.397	32600	13115
200	36	1	34	23.5	-41.4	547.408	30100	12843
210	40	1	0	75.9	-51.4	11.249	28600	9773
220	42	0	1	83.1	40.7	21.782	42500	16252
230	45	0	1	84.5	16.1	7.564	111200	42774
240	46	4	36	15.8	33.4	629.693	36900	16315
250	49	2	18	32.6	5.9	339.813	30400	12093
260	51	0	1	48.4	54.6	12.115	65600	27282
270	55	24	367	-7.8	16.1	7304.989	87500	33835
280	57	3693	9963	-11.3	-3.1	229439.831	600400	244063

290	65	0	2	59.9	-14.0	17.921	43500	15434
300	68	5	34	-31.3	-3.5	654.986	36400	13426
310	69	0	2	0.3	34.3	24.665	32600	11422
320	71	0	3	53.3	-32.2	16.890	61900	22790
330	73	0	1	57.8	-73.4	11.927	79600	23083
340	75	1	10	-10.4	33.4	201.479	38300	17310
350	80	0	4	36.2	30.0	54.320	25600	10757
360	81	0	1	-23.4	73.7	3.956	30500	12228
370	83	9	107	-8.6	-25.3	1925.540	86200	31790
380	101	0	1	-36.0	-53.3	23.607	35365	13620
390	102	0	5	-13.1	-53.1	75.841	87163	20262
400	103	2	3	-26.8	-59.2	187.836	132222	38118
410	104	0	2	-43.2	-48.9	47.221	30332	11837
420	105	0	2	-69.3	8.5	14.380	53304	19447
430	106	0	1	-49.0	25.7	25.029	29620	13665
440	107	1	8	-45.3	1.5	151.920	73242	39585

APPENDIX C

TABULATED DATA FOR EMPLOYEE
AND WAGE DISTRIBUTIONS

1. DISTRIBUTION OF EMPLOYEES
RADIAL DISTANCE FROM WPAFB

HISTOGRAM OF DISTANCES - DATAZ FILE
RADIAL

LESS THAN OR EQUAL TO	NUMBER OF EMPLOYEES
5	12225
10	8516
15	5536
20	1013
25	251
30	258
35	210
40	133
45	47
50	132
55	86
60	39
65	17
70	14
75	4
80	4
85	2
90	5
95	2
100	1
105	0
110	0
115	0
120	0
125	0
130	0
135	0
140	0
145	0
150	0

2. DISTRIBUTION OF FEDERAL PAY
RADIAL DISTANCE FROM WPAFB

HISTOGRAM OF DISTANCES - DATAZ FILE
RECTILINEAR

LESS THAN OR EQUAL TO	AMOUNT OF FED WAGES
5	121223.306
10	154295.115
15	112326.252
20	40301.943
25	17658.100
30	4670.501
35	1959.963
40	3740.323
45	1095.083
50	2364.955
55	1658.018
60	1259.828
65	645.390
70	1735.290
75	709.995
80	458.309
85	97.254
90	91.231
95	36.652
100	0.
105	23.635
110	79.528
115	0.
120	0.
125	21.732
130	19.030
135	11.927
140	0.
145	0.
150	0.

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A
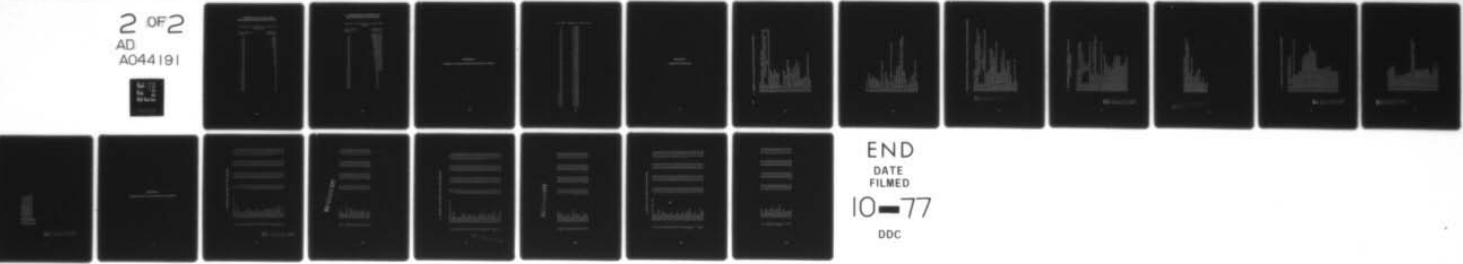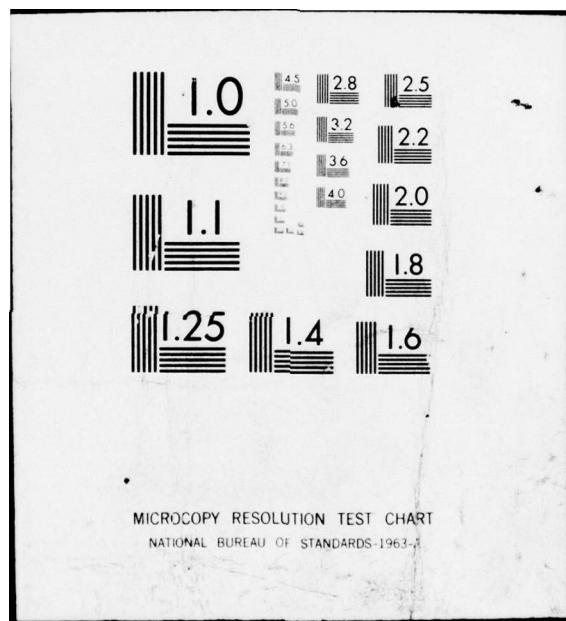
3. DISTRIBUTION OF EMPLOYEES
RECTILINEAR DISTANCE FROM WPAFB

HISTOGRAM OF DISTANCES — DATAZ FILE
RECTILINEAR

LESS THAN OR EQUAL TO	NUMBER OF EMPLOYEES
5	8250
10	9073
15	6774
20	2113
25	1052
30	260
35	119
40	213
45	60
50	139
55	108
60	71
65	37
70	114
75	55
80	30
85	7
90	5
95	4
100	0
105	3
110	4
115	0
120	0
125	1
130	2
135	1
140	0
145	0
150	0

4. DISTRIBUTION OF FEDERAL PAY
RADIAL DISTANCE FROM WPAFB

HISTOGRAM OF DISTANCES - DATAZ FILE
RADIAL

LESS THAN OR EQUAL TO	AMOUNT OF FED WAGES
5	182605.528
10	149093.141
15	97514.256
20	17194.372
25	4307.900
30	4541.342
35	3542.256
40	2290.377
45	723.542
50	2248.976
55	1236.981
60	569.683
65	274.841
70	135.754
75	27.650
80	39.774
85	24.665
90	67.414
95	33.031
100	11.927
105	0.
110	0.
115	0.
120	0.
125	0.
130	0.
135	0.
140	0.
145	0.
150	0.

APPENDIX D

PERCENT OF WORK FORCE EMPLOYED AT WPAFB

CTY CODE	PERCENT OF WORK FORCE
1	0.018
2	0.004
6	0.018
8	0.018
9	0.103
11	1.154
12	5.303
13	0.034
14	1.142
17	0.005
19	0.265
21	0.015
23	0.009
24	0.397
25	0.012
29	13.834
31	0.043
32	0.011
33	0.008
36	0.273
40	0.010
42	0.006
45	0.002
46	0.245
49	0.165
51	0.004
55	1.154
57	5.009
65	0.013
68	0.290
69	0.018
71	0.013
73	0.004
75	0.064
80	0.037
81	0.008
83	0.365
101	0.007
102	0.025
103	0.026
104	0.017
105	0.010
106	0.007
107	0.023

APPENDIX E

COMPUTER PROGRAMS

1. LISTING OF ZIP CODES AND TOWNS FROM PAY RECORDS

```
10#N,R(SL)
20$:IDENT:WP1191,AFIT/SLG - JOHNSON AND WILLIES
30$:****:*****************************************************
40$:****:        THIS PROGRAM LISTS SORTED ZIP CODES AND TOWNS  ***
50$:****:                  DATE                                  ***
60$:****:******************************************************
70$:OPTION:FORTRAN,NOMAP
80$:FORTY:NFORM,NLNO
90 CHARACTER ADD*26(1000)
100 CHARACTER ADDT*26
110 CHARACTER TOWN*26
120 J=0
130 L=0
140 DIMENSION IZIP(1000)
150 DO 1 L=1,10000
160 READ(10,1000,END=999)TOWN,ICODE
170 IF(ICODE.EQ.0)GO TO 333
180 222 DO 2 J=1,1000
190 IF(J.EQ.1000)GO TO 111
200 IF(IZIP(J).EQ.0)GO TO 444
210 IF(ICODE.GT.IZIP(J))GO TO 888
220 IF(ICODE.EQ.IZIP(J))GO TO 1
230 2 CONTINUE
240 1 CONTINUE
250 999 CONTINUE
260 DO 3 I=1,1000
270 WRITE(06,2000,END=9999)IZIP(I),ADD(I)
280 3 CONTINUE
```

```
290 GO TO 555
300 888 IZIPT=IZIP(J)
310 ADDT=ADD(J)
320 IZIP(J)=ICODE
330 ADD(J)=TOWN
340 ICODE=IZIPT
350 TOWN=ADDT
360 GO TO 2
370 333 WRITE(06,3000)L,ICODE,TOWN
380 GO TO 1
390 444 IZIP(J)=ICODE
400 ADD(J)=TOWN
410 GO TO 1
420 111 PRINT,"OVERFLOW IN ZIP CODE FILE AFTER READING"
430 PRINT,L
440 PRINT,"RECORDS"
450 1000 FORMAT(2X,A26,I5)
460 2000 FORMAT(1X,I5,7X,A26)
470 3000 FORMAT(1X,I5,5X,I5,7X,A26,7X,15HIS A BAD RECORD)
480 4000 FORMAT(23HEND OF TAPE FOUND AFTER,1X,I5,5X,7HRECORDS)
490 555 WRITE(06,4000)L
500 9999 STOP
510 END
520$:EXECUTE
530$:LIMITS:15,34K
540$:FFILE:10,MOSLEW
550$:TAPE:10,XID,,####,,INPUT TAPE
560$:ENDJOB
```

2. BREAKDOWN TASK, STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

```
10#JS,R(SL) :,8,16;,16
20$:IDENT:WP1191,AFIT/SLG - 77A - JOHNSON AND WILMES
30$:****:*******************************************************
40$:****:        BREAKDOWN OF WRIGHT-PATTERSON AFB PAY DATA
50$:****:                    DATE
60$:****:            TABLES=GROSSPAY BY ZIP
70$:****:*******************************************************
80$:SELECT:SPSS/SPSS
90$:LIMITS:30,40K,6K,5K
100RUN NAME;THESIS-ECONOMIC REGION OF INFLUENCE
110FILE NAME;WRIGHT-PATTERSON AFB FEDERAL PAY
120VARIABLE LIST;ZIP,ADDRESS,CROSSPAY
130VAR LABELS;CROSSPAY,CROSSPAY IN THOUSANDS OF DOLLARS
140INPUT MEDIUM1;TAPE
150N OF CASES;UNKNOWN
160INPUT FORMAT;FIXED(F5.0,A53,F8.2)
170PRINT FORMATS;ZIP(0)/ADDRESS(A)/GROSSPAY(2)
180MISSING VALUES;ZIP(0)
190COMPUTE;GROSSPAY=GROSSPAY/1000.
200BREAKDOWN;TABLES=GROSSPAY BY ZIP
210READ INPUT DATA
220FINISH
230$:TAPE:08,XID,,####,,INPUT TAPE
240$:ENDJOB
```

3. REGRESSION TASK, STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

```
10#$S,R(SL) :,8,16;:,16
20$:IDENT:NP1191,AFIV/SLG - 77A - JOHNSON AND WILMES
30$:****:*****************************************
40$:****:        REGRESSION OF DATA FILE
50$:****:           TWO FACTORS
60$:****:             DATE
70$:****:            "DATA" FILE
80$:****:*****************************************
90$:SELECT:SPSS/SPSS
100FILE NAME;ECONOMIC IMPACT WRIGHT-PATTERSON AFB, OH
110VARIABLE LIST;ZIP,NAF,MIL,CIV,GRIDX,GRIDY,DELIV,COUNTY,PAY
120INPUT MEDIUM;CARD
130N OF CASES;240
140INPUT FORMAT;FIXED(4(1X,F5.0),2(1X,F5.1),1X,F6.0,1X,
150;F3.0,1X,F10.3)
160COMPUTE;DISTANCE=ABS(GRIDX)+ABS(GRIDY)
170MISSING VALUES;DISTANCE(0.0)
180COMPUTE;NMBR=NAF+MIL+CIV
190COMPUTE;POPUL=DELIV*2.97
200COMPUTE;AVPAY=PAY/NMBR
210COMPUTE;DFACTOR=POPUL/DISTANCE
220COMPUTE;D2FACTOR=POPUL/(DISTANCE**2)
230COMPUTE;D3FACTOR=POPUL/(DISTANCE**3)
240COMPUTE;D4FACTOR=POPUL/(DISTANCE**4)
250COMPUTE;NUMTRANS=LN(NMBR)
260COMPUTE;POPTRANS=LN(POPUL)
270COMPUTE;DISTRANS=LN(DISTANCE)
280COMPUTE;P2FACTOR=(POPUL**2)/DISTANCE
```

```
290COMPUTE;P32FACT=(POPUL.**1.5)/DISTANCE
300REGRESSION;VARIABLES=N1BR,POPUL,DISTANCE,DFACTOR,D2FACTOR,
310;D3FACTOR,D4FACTOR,P2FACTOR,P32FACT,AVPAY,NUMTRANS,
320;POPTRANS,DISTRANS
330;REGRESSION=TWO FACTORS(2) RESID=0/
340STATISTICS;ALL
350READ INPUT DATA
360$;SELECTA:77A/"DATA"
370SCATTERGRAM1;TWO FACTORS
380OPTIONS;7
390STATISTICS;ALL
400FINISH
410$;ENDJOB
```

4. COMPUTATION OF MEAN ABSOLUTE DEVIATIONS

```
10 CALL ATTACH(10,"77A55/DATA2;",1,0,,)
20 CALL ATTACH(12,"77A55/MILFILE;",3,0,,)
30 DO 5 J=1,240
40 READ(10,1000)LINE,ZIP,NAF,MIL,ICIV,GX,GY,DELIV,ICTY,PAY
50 EMP=NAF+MIL+ICIV
60 POPUL=DELIV*2.97
70 DIST=ABS(GX)+ABS(GY)
80 IF(DIST.EQ.0.)GO TO 5
90 ZMOD1=-76.71780+0.29521*POPUL/DIST
100 ZMOD2=35.23257+1.25745*POPUL/(DIST**2)
110 ZMOD3=67.43442+3.90395*POPUL/(DIST**3)
120 ZMOD4=77.86082+11.92591*POPUL/(DIST**4)
130 ZMODT=872.7856561*(POPUL**0.45857)/(DIST**2.41560)
140 ZMODAD=320.04671+0.00475*POPUL-6.22287*DIST
150 ZMODP2=-14.39692+0.00001*(POPUL**2)/DIST
160 ZMODP32=-45.87819+0.00142*(POPUL**1.5)/DIST
170 RESID1C=ABS(ZMOD1-EMP)
180 RESID2C=ABS(ZMOD2-EMP)
190 RESID3C=ABS(ZMOD3-EMP)
200 RESID4C=ABS(ZMOD4-EMP)
210 RESIDTC=ABS(ZMODT-EMP)
220 RESIDADC=ABS(ZMODAD-EMP)
230 RESIDP2C=ABS(ZMODP2-EMP)
240 RESDP32C=ABS(ZMODP32-EMP)
250 RSUM11=RSUM11+RESID1C
260 RSUM12=RSUM12+RESID2C
270 RSUM13=RSUM13+RESID3C
280 RSUM14=RSUM14+RESID4C
```

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```
290     RSUMT=RSUMT+RESIDTC
300     RSUMAD=RSUMAD+RESIDADC
310     RSUMP2=RSUMP2+RESIDP2C
320     RSUMP32=RSUMP32+RESDP32C
330   5 CONTINUE
340     RSUM1=RSUM1/J
350     RSUM2=RSUM2/J
360     RSUM3=RSUM3/J
370     RSUM4=RSUM4/J
380     RSUMT=RSUMT/J
390     RSUMAD=RSUMAD/J
400     RSUMP2=RSUMP2/J
410     RSUMP32=RSUMP32/J
420     WRITE(12,2001)"EVALUATION OF RESIDUALS***************"
430     WRITE(12,3001)"   MEAN ABSOLUTE VALUE OF RESIDUAL.   "
440     WRITE(12,2000)RSUM1
450     WRITE(12,3000)RSUM2
460     WRITE(12,4000)RSUM3
470     WRITE(12,5000)RSUM4
480     WRITE(12,6000)RSUMT
490     WRITE(12,7000)RSUMAD
500     WRITE(12,8000)RSUMP2
510     WRITE(12,9000)RSUMP32
520 2001 FORMAT(A38)
530 1000 FORMAT(V)
540 2000 FORMAT(6HRSUM1=,F12.3)
550 3001 FORMAT(/,A37,/)
560 3000 FORMAT(6HRSUM2=,F12.3)
```

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```
570 4000 FORMAT(6HRSUB13=,F12.3)
580 5000 FORMAT(6HRSUB14=,F12.3)
590 6000 FORMAT(6HRSUBT=,F12.3)
600 7000 FORMAT(7HRSUBHAD=,F11.3)
610 8000 FORMAT(7HRSUBP2=,F11.3)
620 9000 FORMAT(8HRSUBP32=,F10.3)
630 STOP
640 END
```

APPENDIX F

TABULATED DATA FOR MARGINAL ANALYSES

1. MARGINAL ANALYSIS OF CERL METHOD

0	WRIGHT-PATTERSON AFB	N/A	17.94	11.97	N/A
29	GREENE	0.	40.66	36.10	91.597
57	MONTGOMERY	4.0	83.57	82.87	32.758
12	CLARK	5.0	94.94	94.68	30.533
55	MIAMI	6.9	96.31	96.25	23.236
19	DARKE	14.6	96.53	96.48	26.394
83	WARREN	19.8	96.94	96.90	24.903
14	CLINTON	22.2	97.51	97.47	24.347
11	CHAMPAIGN	23.1	98.02	98.05	23.692
49	MADISON	24.0	98.09	98.12	23.243
68	PREBLE	24.9	98.22	98.26	22.592
9	BUTLER	26.5	98.56	98.64	19.021
24	FAYETTE	28.0	98.71	98.78	13.711
21	DELAWARE	30.3	98.72	98.73	13.144
46	LOGAN	34.4	98.86	98.00	17.748
75	SHELBY	35.0	98.90	98.96	17.336
80	UNION	36.9	98.92	98.97	17.079
31	HAMILTON	38.1	99.46	99.52	11.077
13	CLERMONT	39.5	99.51	99.57	10.657
36	HIGHLAND	40.9	99.63	99.69	10.550
6	AUGLAIZE	44.2	99.64	99.70	10.396
107	WAYNE,IN	45.3	99.67	99.73	10.109
65	PICKAWAY	46.1	99.68	99.74	9.956
25	FRANKLIN	46.5	99.84	99.86	7.669
106	RANDOLPH,IN	49.6	99.85	99.87	7.609
102	CAMPBELL,KY	53.9	99.36	99.88	7.437
8	BROWN	56.1	99.87	99.89	7.381
103	KENTON,KY	56.7	99.91	99.93	7.139

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101	BOONE, KY	63.0	99.91	99.93	7.077
33	HARDIN	63.1	99.91	99.94	7.020
1	ADAMS	64.9	99.92	99.94	6.934
2	ALLEN	65.0	99.92	99.95	6.301
104	DEARBORN, IN	65.2	99.93	99.96	6.753
71	ROSS	66.6	99.94	99.96	6.656
23	FAIRFIELD	70.0	99.95	99.96	6.536
105	HENRY, IN	70.3	99.96	99.97	6.458
51	MARION	73.0	99.96	99.97	6.363
81	VAN WERT	79.0	99.97	99.97	6.321
69	PUTNAM	84.4	99.97	99.98	6.276
45	LICKING	86.0	99.98	99.98	6.126
32	HANCOCK	83.6	99.99	99.98	6.045
17	CRAWFORD	90.0	99.99	99.99	5.930
42	KNOX	92.5	99.99	99.99	5.927
40	JACKSON	93.7	100.00	100.00	5.392
73	SCIOTO	95.7	100.00	100.00	5.797

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2. MARGINAL ANALYSIS OF AIR FORCE METHOD

		N/A	17.94	11.97	N/A
0	WRIGHT-PATTERSON AFB	N/A	17.94	11.97	N/A
29	GREENE	3.2	40.66	36.10	91.597
57	MONTGOMERY	5.5	83.57	82.87	32.758
12	CLARK	5.6	94.94	94.68	30.588
55	MIAMI	8.0	96.31	96.25	28.236
19	DARKE	20.2	96.53	96.48	26.894
83	WARREN	22.6	96.94	96.90	24.908
11	CHAMPAIGN	27.2	97.45	97.48	24.360
49	MADISON	27.7	97.52	97.55	23.744
68	PREBLE	29.7	97.66	97.69	23.060
14	CLINTON	31.3	98.22	98.26	22.592
24	FAYETTE	36.1	98.38	98.40	22.147
9	BUTLER	37.2	98.71	98.78	18.711
21	DELAWARE	37.8	98.72	98.73	13.144
46	LOGAN	38.2	98.36	98.92	17.748
75	SHELBY	43.8	98.90	98.96	17.336
13	CLERMONT	45.0	98.94	99.01	16.319
31	HAMILTON	46.5	99.49	99.55	10.759
107	WAYNE,IN	46.8	99.52	99.59	10.452
25	FRANKLIN	50.1	99.69	99.72	7.956
80	UNION	51.7	99.70	99.73	7.901
36	HIGHLAND	52.4	99.82	99.35	7.845
6	AUGLAIZE	53.0	99.84	99.86	7.759
65	PICKAWAY	59.8	99.84	99.86	7.669
106	RANDOLPH,IN	63.6	99.35	99.87	7.609
3	BROWN	67.6	99.85	99.87	7.551
2	ALLEN	67.7	99.86	99.88	7.338
102	CAMPBELL,KY	71.3	99.88	99.89	7.178

23	FAIRFIELD	75.5	99.89	99.90	7.039
103	KENTON, KY	76.3	99.92	99.94	6.818
105	HENRY, IN	78.3	99.93	99.94	6.733
33	HARDIN	81.9	99.93	99.95	6.681
1	ADAMS	85.5	99.94	99.95	6.649
101	BOONE, KY	85.7	99.94	99.95	6.595
69	PUTNAM	87.3	99.95	99.96	6.546
71	ROSS	90.3	99.96	99.96	6.454
104	DEARBORN, IN	92.1	99.96	99.97	6.411
45	LICKING	100.6	99.97	99.97	6.255
81	VAN WERT	102.1	99.97	99.97	6.213
51	MARION	103.0	99.98	99.98	6.126
32	HANCOCK	107.5	99.99	99.99	6.045
42	KNOX	123.8	99.99	99.99	5.991
17	CRAWFORD	126.6	99.99	100.00	5.927
40	JACKSON	128.2	100.00	100.00	5.892
73	SCIOTO	135.0	100.00	100.00	5.797

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3. MARGINAL ANALYSIS OF ARMY METHOD

		N/A	17.94	11.97	N/A
0	WRIGHT-PATTERSON AFB	N/A	17.94	11.97	N/A
29	GREENE	13.834	40.66	36.10	91.600
12	CLARK	5.303	52.03	47.91	52.210
57	MONTGOMERY	5.009	94.94	94.68	30.590
55	MIAMI	1.154	96.31	96.25	28.240
11	CHAMPAIGN	1.154	96.82	96.83	27.510
14	CLINTON	1.142	97.39	97.40	26.810
24	FAYETTE	0.397	97.54	97.54	26.180
83	WARREN	0.365	97.94	97.95	24.310
63	PREBLE	0.290	98.08	98.09	23.600
36	HIGHLAND	0.273	98.20	98.21	23.040
19	DARKE	0.265	98.43	98.45	22.160
46	LOGAN	0.245	98.57	98.58	21.570
49	MADISON	0.165	98.64	98.65	21.090
9	BUTLER	0.103	98.98	99.03	17.960
75	SHELBY	0.064	99.01	99.07	17.540
31	HAMILTON	0.043	99.56	99.62	11.280
80	UNION	0.037	99.58	99.63	11.160
13	CLERMONT	0.034	99.62	99.68	10.740
103	KENTON, KY	0.026	99.65	99.72	10.230
102	CAMPBELL, KY	0.025	99.67	99.74	9.920
107	WAYNE, IN	0.023	99.70	99.77	9.660
1	ADAMS	0.018	99.71	99.77	9.590
6	AUGLAIZE	0.018	99.72	99.78	9.460
8	BROWN	0.013	99.72	99.79	9.370
69	PUTNAM	0.018	99.73	99.79	9.270
104	DEARBORN, IN	0.017	99.74	99.80	9.180
21	DELAWARE	0.015	99.75	99.81	9.050

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ID	Name				
65	PICKAWAY	0.013	99.75	99.81	8.920
71	ROSS	0.013	99.76	99.82	8.760
25	FRANKLIN	0.012	99.93	99.94	6.940
32	HANCOCK	0.011	99.94	99.95	6.830
40	JACKSON	0.010	99.94	99.96	6.790
105	HENRY,IN	0.010	99.95	99.96	6.700
23	FAIRFIELD	0.009	99.96	99.96	6.580
33	HARDIN	0.008	99.96	99.97	6.530
81	VAN WERT	0.008	99.97	99.97	6.490
101	BOONE,KY	0.007	99.97	99.97	6.440
106	RANDOLPH,IN	0.007	99.98	99.98	6.390
42	KNOX	0.006	99.98	99.98	6.330
17	CRAWFORD	0.005	99.98	99.99	6.260
2	ALLEN	0.004	99.99	99.99	6.120
51	MARION	0.004	99.99	99.99	6.030
73	SCIOTO	0.004	100.00	99.99	5.930
45	LICKING	0.002	100.00	100.00	5.770